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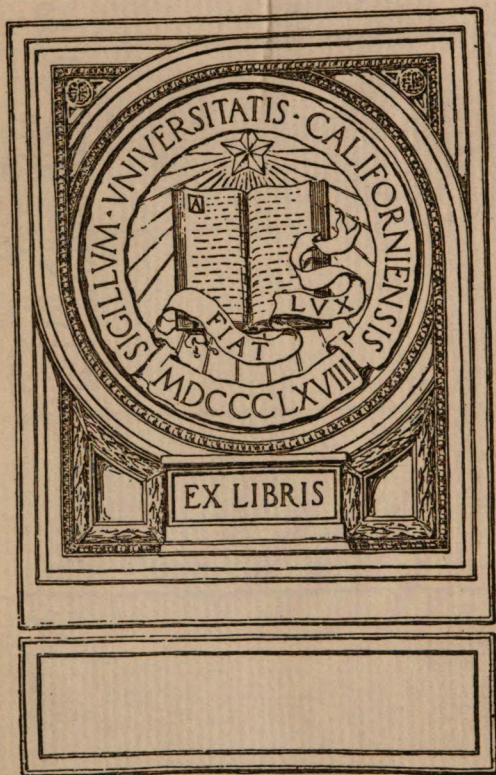
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A FOREST SURVEY OF THE TOWN OF REDDING, CONN.

BY
ALBERT E. MOSS, M.F.

GIFT
OCT 10 1930

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A Forest Survey

OF

The Town of Redding, Conn.

By ALBERT E. MOSS, M.F.

Assistant Forester.

The Forest Survey of Connecticut, published as Part III of the Annual Report of the Connecticut Agricultural Experiment Station for 1915, was intended as a general study of the forested lands of the state. Although the forests of each county were described in a general way, and the area of forest land estimated for each town, no more specific studies were attempted. It was felt that the expense of making a detailed survey would not be justified, and that one of a general nature would be of more immediate value.

Increasing interest in forestry in certain towns, however, indicated need of further information regarding particular localities. With a view to determining the expense involved in an intensive survey, the best methods to be used in making one, and the results to be expected from it, a study of the town of Redding was undertaken in the summer of 1915. Redding was chosen because of the interest shown there, and because the forest conditions are fairly typical of Fairfield County. The published results should be of especial interest to towns where similar conditions prevail, and will suggest the possibility of similar studies in all the heavily forested towns of the state.

The present town of Redding was included in the land purchased from the Indians for the town of Fairfield in 1639. The earliest survey in 1640 did not include the land between the Ridge-Center road and the present Bethel town line, but this was added to Fairfield before 1725. The first settlement was about 1700 and by 1760 there was much talk of separating Redding from Fairfield. The act making Redding a town was

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passed in 1767 when the population was about a thousand. Since then the original town lines have been very closely adhered to.

The town is situated in the southwest portion of the state within the western upland. The elevations range only from 300 to 800 feet and the topography is fairly regular with three ridges and four valleys running north and south. The streams are small and drain directly into the Sound. The valleys are narrow, occasionally widening into small level areas subject to overflow in the spring. The ridges are rounded and contain the greater part of the agricultural land. Many small streams rise in swamps scattered over the ridges, and flow into the main streams during wet seasons. Most of these streams do not have a drainage area sufficient to carry them through a dry season.

The location of the town between the turnpikes from New York and Poughkeepsie to Boston, and the general topography, led to the early development of north and south roads connecting the inland and the coast towns. The present Ridge Road is the only turnpike that crossed Redding in this direction although the Danbury to Norwalk road followed its western edge. The main east and west road across the town was the Newtown to Ridgefield turnpike, now the Ridge-Center road. As the first settlements were on the agricultural lands of the ridges, the lines of communication followed these instead of the valleys. The narrower valleys and the slopes were not as accessible and were left in forest. The town was not situated near markets or raw manufacturing material, so that while the water-power was developed to some extent, agriculture was always the most important industry.

The industrial census of 1845 shows that the manufactures were adapted to the local demand, and but little importation of products was needed. The dairy showed perhaps the best development, although cereals were always important. In 1845 the crops listed were as follows: corn 13,680 bushels, oats 18,500 bushels, potatoes 12,000 bushels, butter 63,500 pounds, cheese 11,780 pounds. Sheep were valued at \$1,700 with a wool yield of \$1,280. These crops were either sold locally or exported to New York. The list of manufactured products of the town shows a very close relation between the forests and the industries. The iron foundry and furnace listed used charcoal for fuel, and some 20,000 bushels valued at \$2,000 were burned in the

town. The wagon and cabinet factories with an annual output valued at \$14,000 depended on local lumber to a large extent, and at least 1,000,000 feet were cut locally that year. Four or five water-power mills were used in cutting this material. Some 95,000 bricks were burned during the year. With the lime kilns this made a demand for cordwood, a portion of which was supplied by the farmers of Redding with a cut of 425 cords valued at \$4 per cord. Brooms were also manufactured in the town.

At that time the value of the forest to the inhabitants of the town was much greater than it is at present. Methods of transportation were so poor that the inhabitants were dependent on the forests for fuel to heat their buildings, as well as for the other uses mentioned above. The best of the timber went into saw logs, and probably only the tops and poorer trees were used as fuel and for charcoal. The relatively small quantity of lumber cut was due to the heavy cost of hauling the logs to the mills and the sawed product to market. The introduction of the portable mill and cheap coal caused great changes in the handling of the woodlands. Now the logs are sawed in the woodlot, and only the sawed material is hauled out. The decreased demand for wood and the total elimination of charcoal from the market has made lumbering operations as conducted at present much more wasteful than formerly.

The town probably reached its greatest industrial development in the years just prior to the Civil War, and as was the case with many other towns of the state, rapid decline followed from which it has never recovered. With the loss of the younger generation, either in the war or by their emigration to the West, the cultivation of much of the land has been abandoned, and crops formerly exported are now brought from the farms of the West. Since the war, only the best of the land has been cultivated, and the remainder allowed to come up to timber or brush. Within the past few years there has been a more general movement of city people towards the country for at least part of the year. Situated as it is within commuting distance of New York, Redding has been much affected by this movement. The greater part of the city people do not live in the town throughout the year, although they spend most of the summer there.

This influence of the summer resident throughout the region results in abnormally high land values compared with actual

agricultural values. The amount of capital necessary to establish a farm is so great that transfers of property for that purpose are infrequent. The business man has introduced his methods into farming, however, so that better results in marketing and purchasing supplies are offsetting the high capitalization necessary to carry on the industry in this region. With this renewed interest in agriculture there have been developed more intensive methods of management, and the area of land cultivated has been decreased, with improved results in many instances. The two influences have balanced to a certain extent, but at present there seems to be a slight gain in the amount of land cultivated in some portions of the town.

The slow transportation of the early part of the nineteenth century necessitated manufacturing dairy products before shipment to market. Changes following the Civil War developed the manufacturing centers at the expense of the farming communities of the state. This concentration of the population in the cities developed a market for milk which is either supplied by the adjoining region or shipped in by rail. The eastern portion of the town was within direct hauling distance of Bridgeport, and the demand for milk has led to the closing of local creameries. Since the advent of the motor truck this influence of the city market is being extended, and better service is given the producer. The manufactured dairy products formerly produced locally are now imported from the western dairy regions. Fruit growing is increasing in importance in the western part of the town as the markets are brought nearer by use of the motor truck. The farms owned for the pleasure they give the owner are usually in one or the other of the above classes. With the increased ease of transportation there is an increasing number of permanent residents from the cities, and an increase in the agricultural land as a result.

In all probability the changes in transportation have had the greatest effect on the forest area of the town. The early manufacturing depended on the use of local woods to a great extent. The iron foundries used native charcoal, the chair and cabinet shops used local material, as did the wagon and carriage shops. The fuel used was entirely wood, and during the period just prior to the development of the railroad there was much talk of a wood famine. The development of the railroads made avail-

able the vast timber supply of hard and soft woods in the West and South. Coal also became the common fuel, and the problem of a timber shortage was eliminated for many years. The forests of the town were neglected except for small local demands for timber, and for poles or railroad ties. The wood-using industries moved to the source of supply, the forests began to revert to their former condition, and the forest area of the town began to increase with the seeding in of the abandoned lands.

During the past ten years there has been a change in the attitude taken towards the local forests, and with the increase in cost of material from other sections of the country, the local products are again finding their way into the markets. The use of wood for fuel, except for the burning of lime, is only in individual houses, as coal has driven cordwood out of the market for general purposes. There is no charcoal burned in the region at present, and the small quantities used are imported from the wood distilleries of New York and Pennsylvania. The local demand for timber is largely in Georgetown, 350,000 to 400,000 feet of sawed material being used there annually. Of this amount the town supplies practically nothing, although if native oak and pine were obtainable it might supply seventy-five per cent of the demand. The native timber used is largely in the form of plank or dimension material. The lime-kiln in the northern part of the town will take all cordwood within hauling distance, but the prices paid limit the haul to very short distances. This demand for small material makes intensive forestry work possible in this section of the town.

TREE SPECIES.

The distribution of tree species in the United States is limited more directly by climatic than by soil conditions. Maximum and minimum temperatures with rainfall and atmospheric moisture are the limiting factors in their geographic distribution. The range of an individual species may be extended in any direction by changes in elevation that produce the necessary climate.

Connecticut is located along the meeting line of the northern and the southern species, and is not in the optimum range of any tree of commercial importance. Chestnut perhaps came the

nearest to reaching its optimum here, but even this tree attains greater size in the mountains of Tennessee and Kentucky. Gray birch, a relatively unimportant species, is at about its maximum development in this state. Whitewood or tulip, chestnut, the oaks, the hickories, white ash and black birch are some of the southern trees found in this region. White pine, hard maple, paper birch, yellow birch and hemlock are some of the northern trees that occur here. This is known as the "Sprout hardwood region" because of the almost universal occurrence of species that coppice abundantly. This feature of the forest has enabled continued cutting of the wood on a short rotation without regard to seed years or the establishment of reproduction. Even fire will not ordinarily entirely destroy the stand, although repeated burning will reduce its vitality and change the predominant species.

Although there are at least fifty tree species found within the town of Redding (see page 46), there are relatively few that are of economic importance and only ten are of commercial value. Most of the species occur but rarely, or are of poor quality and inferior form, so that they may be compared to the weeds of the farm.

As on the farm, the weed species are the easiest to reproduce and will occupy vacant land much more readily than the more valuable species, since the former are less exacting than the latter as to soil and moisture requirements of the seed-bed and the seeds are much more widely distributed by the wind or birds. Weed species may prove of some value in forming suitable conditions for future forest development. The weed species as a rule are short-lived and exacting in light requirements, so that the better species are able to crowd them out in the end. Many species, neither weed nor commercial, form an underwood in the more mature forest, and help in the preservation of the forest floor.

White Pine (Pinus strobus).

This is the most valuable native tree of the region. In the forests found by the colonists the area occupied by this species was much greater than at present. The wood was the easiest worked and best of any found in the colonial forests, and as a result was very largely exported to England. While the species

probably never occupied a very large percentage of the area, the wide distribution of the remaining stands shows that it must have been common throughout the entire town. Pine only reproduces by means of seed and is at a disadvantage in competition with hardwood coppice. The seeds are borne in cones requiring two years to mature. Wings aid in their distribution by the wind, but the seed-bed requirements, together with rodent and bird damage, reduce the number of natural seedlings very greatly. Growth during the early stages is very rapid and a mature stand is much denser than a stand of hardwoods. The product is used for box boards, building material and wherever light, easily worked wood that will keep its shape is desired. Pattern makers use large quantities of the best grades, mostly obtained from the virgin stands of the West. This is the only native species that shows satisfactory profits in plantations, although the red pine of the Lake States gives great promise in recent plantations. Some of the oldest plantations in Connecticut are white pine, and many younger planted stands are now growing throughout the state.

The tree has two serious enemies at present, one an insect and the other a fungus, the insect being perhaps the more serious in this region. (See page 39.) The trees are thin-barked and easily killed by fire during the juvenile stages, but later in life become more fire resistant. The stands prune well, forming clear straight trunks that carry their diameters well into the tops.

Red Pine (Pinus resinosa).

This tree occurs rarely within the state, but to the North, especially in the Lake States, it grows with white pine, and is logged at the same time. The mature tree is not as large as white pine, but the growth during the early life of the two species is very similar. Red pine has no insect or fungous enemies at present, and is being favored in planting in this region. The wood is harder and stronger but not quite so valuable as white pine. The tree is not as easily injured by fire, and will grow on much poorer soils to good advantage.

Hemlock (Tsuga Canadensis).

This is one of the most admired trees of the town because of its habit of growing near the streams. It is not particular as

to soil requirements, but demands atmospheric moisture for the best development. As a result it is found near streams or in the narrow gorges, and on the steep north slopes of the valleys. Hemlock is very tolerant, and seedling reproduction will come in on the moss and duff under the dense shade of mature trees. Its growth is very slow, and trees fifty years old are often only ten feet high. Removal of the overwood, admitting more light, increases the rate of growth considerably, but at best hemlock is of slow growth. Suppressed trees retain the ability to recover and grow for a long period. Its habit of growth makes this tree very important in this region, from the aesthetic standpoint rather than for its forestry value. The increasing importance of the town as a place of summer residence should indicate to the townspeople that every effort must be made to preserve the scenic beauty of the roads. The valleys are in many cases narrow and their slopes are the natural sites for hemlock. The foliage of the tree is very dense, forming deep shade, and its tolerant character tends to produce a stand of all heights, making these valley roads very attractive even in winter. As there are only a few areas of these evergreens within the town, the contrast with the more common deciduous trees is very pleasing at all seasons.

Although hemlock reproduces well naturally where there are suitable seed-bed conditions, it is very hard to handle in the nursery and the cost of planting stock is high, so that natural reproduction must be secured in most cases. The trees do not prune well naturally, so that the timber is knotty as a rule, and overmature stands are apt to be very defective. Both heart rot and a separating of the growth rings called "ring-shake" are the common defects. The lumber is used as dimension material or rough boards.

Chestnut (Castanea dentata).

This is one of the most rapid growing trees of the region, and has been one of the most important hardwoods of the state. The species must be largely eliminated from future consideration because of the ravages of the chestnut blight (*Endothia parasitica*). It was formerly found on all sites except those subject to flooding, but formed the dominant part of the stand only on the better drained, deep soils, as more drought resistant species

crowded it out of the dry sites. The tree grows well, pruning readily, and forms a clean, full bole whether grown pure or in mixture. The lumber is of good quality and very durable in contact with the soil. It has been the chief source of supply for ties and poles within the state.

Red Oak (Quercus rubrum).

This is the most northern species of the oaks and its range extends well into Canada. The tree is the most valuable of the black oak group within this region and grows to a large size with good form. It is rapid growing in the juvenile stages, either from seed or coppice. The species demands better soil and moisture conditions than chestnut for its best development, but is less exacting in light requirements. The mature tree has a well formed, full bole, pruning well but with widespreading heavy crown. The timber is coarse-grained compared with other oaks and is not so durable as chestnut. It can be treated with preservative rather easily, however, and should be of great importance for this reason in the future.

With the loss of the chestnut this tree is one of the few hardwoods capable of taking a dominant place in the forest which can be profitably handled. Its root growth in the seedling stage is such that it may be grown in a nursery and transplanted with success. The soil and moisture requirements are similar to those of tulip, and it might be planted to good advantage where the latter species occupies a portion of the area naturally. Tulip will not produce good forest conditions alone, but in mixture with the red oak forms a valuable stand. Red oak is capable of producing good stands if planted pure. It should be favored in all woodlot operations, and the better formed trees left when thinning for cordwood.

White Oak (Quercus alba).

This is the most valuable of the oaks native to the United States. The species is at its best in the Mississippi River drainage basin, and is near the northern limit of its range here. However, it has always been important in the development of the industries of the region. The wood is of high quality and largely used where great strength is needed, as in wagon parts and ship timbers. Its close grain and lack of odor or taste has

made it a favorite in tight cooperage. Its use for this latter purpose has not been important in this region, however, since colonial days.

The tree is of slow growth even on the best of soils, and while persisting under shade, it will not recover if suppressed too long. It is common on all areas except those subject to flooding, but is of commercial value only on deep, well drained sites. Pure stands may occur over very limited areas, but mixed stands are more common. Red oak, chestnut, ash, tulip, and other species of less importance are its common associates. The present use of the timber is for ties, carstock, plank and ship timber. Its slow growth with relatively short merchantable length tends to eliminate this tree from forests under management. Because of the high quality of the wood, natural growth may be aided, but new stands will seldom be established.

Tulip (Liriodendron tulipifera).

This is one of the most important hardwoods of the southern Appalachians, with a range extending into Southern New England. It is an intolerant tree, exacting as to soil and moisture requirements, growing best on moist, deep soil not subject to flooding. It makes very rapid growth during the juvenile stage, which continues until the tree reaches its maximum growth. For natural production, it seems to be necessary that the surface mulch should be broken up so that the seed may easily reach mineral soil for germinating. This tree forms the cleanest stem of any in the region, and carries its diameter well into the top. It grows vigorously for many years, often living for one hundred and fifty to two hundred years and reaching a diameter of three feet, with a height of two hundred feet. The wood is used for many of the same purposes as white pine, and is also valuable for veneerings and auto or carriage bodies. It is light, soft, uniform in grain, and does not split easily, but is not durable in contact with the soil.

Tulip is one of the most valuable trees to encourage in place of chestnut in the hardwood forests. It is free from insect and fungous damage, but the seedlings are hard to raise in a nursery. The seed is very infertile and natural reproduction is poor, as a rule, thus limiting the spread of the species. The tree will not produce good timber in pure stands, as its shade is not sufficiently

dense to ensure natural pruning. It should therefore be handled in mixture with other rapid-growing species. Where these are not present in the natural stands, tulip reproduction should be encouraged by the removal of inferior species, and supplemented by planting red oak or pine in the openings thus made.

Red or Soft Maple (Acer rubrum).

This tree occurs throughout the eastern half of the United States, but attains its greatest size in the Mississippi Valley. In this region it is the typical tree of the swamps where it occurs either pure or in mixture with black ash and elm. The stands will endure flooding for long periods and it is about the only tree in the region that will mature in the wetter swamps. Its commercial value is not great, as the lumber is of small size and inferior quality. It is usually cut for cordwood with a maximum rotation of twenty to thirty years. A longer rotation will reduce the sprouting capacity of the stumps, at the same time failing to secure the best returns from the rapid growth of the young stands. This species will produce a crop on sites not suitable for any other, which is its greatest value from the forester's point of view. The tree has some aesthetic value because of its red blossoms early in the spring and bright foliage in the early fall.

FOREST TYPES.

Under natural conditions, trees tend to associate in communities, each individual having its own life history, and each exerting a direct influence on its neighbors. They must compete with each other for moisture and light in order to grow, and each species has developed certain characteristics that enable it to survive in the struggle for existence. Differences in these characteristics cause each species to predominate on the soil and moisture site conditions to which it is best adapted. The grouping of the tree species in a given region is fairly uniform on similar site conditions, since the same external influences tend to cause the same differences in composition. Such typical groupings or associations of tree species are termed *forest types*.

The following types are distinguished in this report: Mixed hardwoods, old field, swamp maple, oak, chestnut, oak-chestnut, hemlock and pine. The classification is based almost entirely on

the composition of the stand, but as the area is small, the composition indicates the site conditions very clearly. External influences, such as chestnut blight and forest fires, have converted some of the stands into other than the original types within the past few years, and the process is still being carried on, especially in the chestnut and the oak-chestnut types. The types merge into one another with changes in site so that a sharp dividing line is hard to define.

Mixed Hardwoods Type.

This is the most common type of the region and its composition varies with the location within wide limits, commonly containing a large number of weed species and a few scattering commercial trees. The type is natural in some sites, but in others it is the result of damage or changes due to methods of handling. On the moist rocky sites that approach the swamp type but are not subject to flooding, the natural mixture is yellow birch, sugar maple, black birch, elm and ash. Natural reforestation of abandoned land often results in a mixed stand in which a large number of species may be present for the first few tree generations, but eventually the type will revert to one that is natural for the site. Change in type effected by damage is illustrated in the elimination of chestnut by the blight, leaving a large number of inferior species none of which are dominant. Cutting in the oak-chestnut type may result in similar conditions with the removal of these commercial species. The type in general promises profitable results from management in the future. Cuttings should be so made as to assure the reoccupation of the area by species at least as valuable as those cut. The trees to be favored and their reproduction protected are tulip, oak, ash and hickory. At present the percentage of tulip seems to be increasing as competition with chestnut decreases. Introduction of pine by planting is advised where cuttings are made as it will increase the productivity of the area.

Old Field Type.

This type is the result of the abandoning of pastures or cultivated land. Its composition is mostly of the light-seeded species like gray birch, or those spread by the birds such as red cedar. The stands are uneven-aged and rather open as a rule, but

density increases as seeding in from the original trees progresses. Under established tree growth there is very little underbrush, but in the open, shrubs may occupy the ground at first.

The life history of this type may be detailed as follows: Land abandoned after cultivation passes through the pasture stage with a gradual increase in the tree growth. This is at first noticeable along the borders of adjoining woodland and along the fences. Light-seeded species are the most common, but those with edible seeds are soon brought in by birds. Clumps of brush appear in the open lots and around the rocks. Even though cut over a few times to save the pasture, the tree species only coppice more vigorously. As a rule, such species mature very early and seeding in then becomes more rapid. The clumps of brush serve to catch and hold wind-blown seeds, and are themselves soon crowded out by trees which they have helped to establish.

Gray birch is perhaps the best adapted of Connecticut trees to afforest such lands naturally because of the seed production, methods of distribution and seed-bed requirements of the species. The cone-like fruiting bodies produce many small, two-winged seeds which ripen in the fall. These cones fall apart during the winter and the seeds are scattered on the snow. They germinate best in mineral soils, so fields with scant humus are the ideal places. Birch forms a nurse crop for better species of forest trees that are not able to seed in on open lands, but take advantage of improved conditions produced under other trees. This natural succession of species is very slow, and to afforest such an area naturally with a commercial species requires a long time.

Small waste areas are found on most of the farms and this type is one of general distribution throughout the town, but it is most common in the western half. It is largely due to economic changes in the community, such as those following the Civil War which were responsible for more abandoned land than any other single cause. Although some of this land is being reclaimed at the present time, intensive cultivation of the present farms tends rather toward the abandonment of more land. It is at present one of the types most needing attention within the town, as it is not producing anything. If left to nature, many years must elapse before such areas can become productive. In

fact, the owners are paying taxes on the land without any immediate prospects of returns sufficient to pay interest on their investments.

The type occupies some of the best land not now under cultivation, and from the forester's standpoint has great possibilities. Eventually much of the land will doubtless be cleared again for agricultural purposes, but in the meantime there is no reason why the owner should not be getting some returns in the line of forest products. The growing of trees tends to increase the fertility of the soil by depositing on the surface of the ground vegetable material containing much mineral matter. This mineral matter drawn from the lower soil by the roots, is used in the life processes of the trees, a portion of it being returned to the soil by the falling and decay of leaves and twigs. In this way the growing of a crop of timber will increase the future productive capacity of such land. These waste areas alone, if properly planted and managed, would produce more timber than the whole town does at the present time.

Swamp Maple Type.

The region is characterized by numerous hard rock ledges that cross the drainage, forming natural dams. On their lower reaches, the streams as a rule have cut through these, making sufficient fall to prevent swamping, but near the head waters and in the depressions of the ridges there is very little drainage. As a result sediment and vegetable matter has collected until the flow areas have been filled flush with the dams, thus making numerous small level tracts subject to flooding. The soil is very rich and in some cases would make fine farm land, but the cost of drainage and clearing is too great to warrant it at present. Small narrow areas of this type may be found near all the streams where local conditions are suitable.

As the name indicates, the type tree is the red or swamp maple. Other species such as alder, elm and black or splinter ash are also common. While red maple never grows to large size, the stands are often dense, so that it is a good cordwood proposition where there is a market for the product. Its rapid growth during the juvenile stage makes it most profitable to handle this type on a short rotation of twenty-five to thirty years. In this way the possibility of failure to secure coppice reproduc-

tion is eliminated, as the species does not begin to lose its vitality until later in life.

The type is very generally distributed throughout the region, especially on the divides. While the established species is of small value, the site conditions are such that there is slight possibility of changing to a more valuable one, except in isolated cases. Draining the swamps for agriculture will probably be a slow development in this region, and the substitution of a better tree species should be attempted wherever the land is not subject to flooding.

Oak Types.

The oaks are the most common tree species in the town. While formerly second in value to the chestnut, they are at present the more important, due to the damage caused by chestnut blight. The species differ greatly in soil and moisture requirements, and the oak type may be found under all conditions with species varying according to site. The timber qualities and rates of growth of different species of oaks also vary greatly, and even in the same species vary with the site. At least eight species are found within the town. The more valuable are white, red, chestnut, black and scarlet oak, while pin and swamp white oak are of relatively rare occurrence. Scrub oak is the least valuable, being one of the most persistent forest weeds.

The most valuable oak type is the result of eliminating chestnut from mixed stands on bottom and lower slope sites, leaving the oaks as the dominant trees. These stands are of relatively small extent as there are a large number of species that compete for such sites, resulting in a mixed hardwoods stand in most cases. Red, white and black oak are the species found under these conditions. The type is slower growing than the chestnut type, but is one of the most valuable in the town for timber, and one that may pay to manage by favoring the better formed trees in making cuttings.

Two other oak types form by far the greater part of the oak stand, but are of relatively little value. The better of these is the ridge type in which the scarlet, and chestnut or rock oak are the principal species. This is usually in pure oak stands on shallow ridge soils, but other species appear as the soil and moisture conditions improve on the slopes. These two oaks are

both capable of making good growth on the better soils, but are not able to compete with other species there because of the limited amount of shade they can endure. Chestnut oak is the better of the two and is used for ties. On the better soils it is capable of fairly rapid growth. Both of these trees are well adapted for a cordwood rotation, as they coppice well and there is usually advance seedling reproduction on the ground. Their light shade allows a fairly heavy ground cover of such shrubs as *vaccinium* and *viburnum*.

The scrub oak type results from repeated burning of the oak ridge type. The present growth is of no value except that it covers the ground and develops a better condition of soil which has been damaged by fire. The converting of this type to a more valuable one is important, especially in the western part of the town. The best method to use would probably be underplanting with a desirable species, later removing the oak in a series of liberation cuttings as required for the development of the planted trees. The final elimination of the scrub oak would be accomplished by the shade of the introduced species. The site is not as good nor the conditions as favorable for reforestation as in the old field type, and the scrub oak type might well be left until the old fields are reforested. Better fire protection is necessary if there is to be any improvement in this type.

Chestnut Type.

Chestnut was once the most important timber tree of the region, but the blight has in recent years very nearly eliminated it. There are a few pure stands left but present conditions seem to indicate that the tree will soon be a thing of the past from the lumberman's standpoint. Chestnut grew on almost all sites not subject to flooding, forming an increasing percentage of the stand until on the better class of well-drained slopes a pure chestnut type was found. This was the most rapid growing type of the region, and was of the greatest commercial value.

The growth habit of the species produced stands of two distinct forms:—one a dense coppice of rapid growth up to fifty or sixty years and reaching maturity at about that age; and the other largely made up of seedling trees which, having a slower juvenile growth, continued to increase in volume for one hun-

dred to one hundred and fifty years, forming a much larger tree of somewhat more open crown with a larger number of other species in the stand. The former was the more valuable for the production of poles and ties, as well as of importance for handling on short cordwood rotation, while the latter produced the better grades of sawed material, such as boards and plank. With the cutting of these stands, some rapid growing and commercially valuable species must necessarily be artificially introduced to replace the chestnut, as the remaining trees of value are not capable of doing it.

Oak—Chestnut Type.

This type is a fairly uniform mixture of oak and chestnut, with other species forming a small percentage of the stand. The type is in a transition stage at the present time, as the chestnut is disappearing and oak and other species are beginning to fill the vacant spaces. Because the chestnut is often left until the remaining species are large enough to cut, the change is somewhat slower and not so noticeable as in pure stands of that species. The type was not so productive as pure chestnut, but more so than pure oak, and has been of considerable value to the owners. In the northern part of the town its handling on a short cordwood rotation was very common. The species of oak in mixture with the chestnut varies with the site conditions. In the same way the productive capacity of the type grades from a maximum in the bottom lands to a minimum at the upper limits where it merges into pure oak. The oak species on the bottom lands are red and white, changing to red, black, white, scarlet and chestnut oak on the slopes, and finally to pure scarlet and chestnut oak stands on the ridges.

The substitution of some other rapid growing species in place of the chestnut is essential as the latter is cut out, if the productive capacity of this type is to be maintained.

Hemlock Type.

Hemlock is one of the most exacting trees of the region as to site and environment. A cool slope near a stream or other body of water where there is plenty of atmospheric as well as soil moisture produces the best growth. The tree is very tolerant and reproduces well under the densest shade. This enables

it to shade out other species on the suitable sites and eventually form pure stands. Its rate of growth is very slow at best and while the tree reaches large size, its greatest value in this region is from the aesthetic side. The roads follow many of the suitable locations for the species, and it is of much value because of its attractive habits of growth. The commercial importance of the type is small, as the growth is very slow and the product usually of inferior quality. The type can be handled best by the selection system, removing the defective and larger trees, as the reproduction can stand great shading for a long period and still recover its normal rate of growth if liberated.

Pine Type.

The two species of pine native in the town are white pine which is of importance as a timber tree throughout the northeastern states, and pitch pine which is generally a scrub tree of little commercial importance. Both species are of only local occurrence and of slight commercial importance within the town. Pitch pine forms one open stand at the summit of a small hill on the western side of the town near Georgetown. The site is very exposed and the growing conditions such that other tree growth is almost lacking because of repeated burning. White pine forms a small portion of the stand in the central and eastern parts of the town, but has been mostly introduced there artificially in the reforestation of waste land.

White pine is one of the best trees for forest management as it grows rapidly, in dense, pure stands, and with a large yield per acre. It will not do well on land subject to flooding, but is well adapted for most other sites. A third species, the Norway or red pine, is found within the town in forest plantations, but does not occur naturally here, although native to the extreme northern part of the state. This species is more resistant to insects and fungi than white pine, and is being used in increasing amount for reforestation work in the state.

FOREST DESCRIPTION.

The forests of this region are at present a mixture in which the weed species are the most common, as a result of improper cutting and damage caused by fire and disease. In a region

where there is very little market for cordwood the disposal of such material is a hard problem. Under present conditions there is very little hope of natural improvement in the stand, as the weed trees are best able to hold the land. These trees are usually well equipped by nature for rapid spread into the openings before the more valuable species are able to get a start, with the result that they occupy more area with each cutting.

The best methods of management for these areas involve the artificial introduction of more valuable species wherever possible, with the expectation that they will increase in numbers by natural reproduction. At the same time cuttings should favor any valuable species already on the ground. In the woodlot the cutting of cordwood for home use forms one of the easiest methods of improving the stand. Such cuttings should take out the poorer species such as birch, maple and elm, as well as inferior trees of the valuable species. The openings thus made should be planted with trees of commercial value and rapid growth. This planting will not take much time, and the cost of the stock is not very great. Such a selection of fuel wood followed by planting will eventually make the forest one of only valuable species. This will increase the rate of growth for the thinned stand left, as well as for the rapid growing species introduced, and the final yield will be much greater than for the original unthinned forest.

In the northern part of the town there is a market for cordwood which will permit clear cutting followed by planting. The brush may be piled and burned to lessen the fire danger, or may be scattered so that planting will be possible. Over the remainder of the town there is less market for cordwood, and the cuttings are for lumber, only the valuable trees being removed. The trees remaining are in very bad shape as a rule. As the lumberman only buys the timber he has no interest in the future crops, and his men fell the trees in the easiest way without regard to reproduction or immature trees that may be on the ground. This results in the breaking of much young growth, and the leaving of large weed trees to seed in the vacant areas. Tops are left unlopped and form a bad fire danger, especially if the cutting is in summer when the leaves are on the trees. On such areas it is advisable to have an understanding with the lumbermen that care will be used in felling to protect the younger trees, and also

as to the disposal of the tops. Lopping or "limbing to the tip," as it is sometimes called, is perhaps the best way to dispose of them where burning is impracticable. This allows the limbs to lie in contact with the ground where they rot much more quickly than in the air. After logging, such areas should be planted, scattering the plants in the openings where they will not be unduly shaded.

Areas that are not producing a crop at the present time present a different problem. They are of two classes, the old field and the scrub oak types. Of these the former is the easier to handle and is the one in which the most work should be done in the near future. As a rule the old field is not only good forest land, but present ground conditions offer very little hindrance to planting operations. When there are open conditions with bunch grass or low brush and a few scattering clumps of trees, planting is done without regard to the tree growth, unless there are wide spreading pasture trees which should be removed for cordwood. Spacing the trees six feet apart each way requires 1,210 trees per acre, and assures the establishment of forest conditions at an early age. The planting up of such old fields promises the best returns on the money invested of any operation in forestation.

The second class of non-productive land is the scrub oak type which occupies a minor area in the town, and follows the repeated burning of an oak type which has impoverished the soil to such an extent that the better class of trees can not compete with the more hardy scrub oak. This species sprouts very vigorously after a fire, and seems to increase in numbers every time an area is burned. The final result is the elimination of the better species for a long term of years, and the loss of returns from the land for a much longer time. Natural reforestation with a valuable species is very slow in such cases and may never take place. Scrub oak is a light-requiring tree and if once shaded will soon die out. This fact may be taken advantage of in artificial forestation, as the stand could be planted with a species that would grow under more or less shade and eventually grow up through the scrub oak to supplant it.

While there are a few areas of unbroken forest in the town, the greater part of the tree growth is in the form of woodlots connected with the farms. These woodlots are more or less isolated, many being surrounded with cultivated land and having

very little fire danger. There are no large holdings entirely within the town, but some of the larger estates include considerable forest land. Since the town is naturally divided into three ridges and four valleys extending from north to south, these natural divisions will be followed in the description of the forest areas.

Aspetuck Valley Area.

This stream rises in the northeast corner of the town and flows south near the eastern border. The head waters are in a large estate where the forest is highly prized for its aesthetic value. All parts of this tract are accessible by means of fine roads, and much improvement work is being carried out in the woods. The chestnut is being removed where necessary, and the resulting stand will be oak on the ridges, changing to mixed hardwoods on the slopes and bottomlands. The mixture includes black and yellow birch, ashes, maples, oaks, hickories, tulip, and other less important species. The swamp species are soft maple and black ash with some elm. Very little planting has been carried out here as yet, but probably much of the area opened up by the removal of the chestnut will be reforested in this manner. This and an adjoining estate include some of the oldest stands in the town.

Near these areas but lower down the stream is a ridge on which the topography is not as broken, and here the forests have been cut solely as a commercial proposition. The species are largely oaks of somewhat inferior quality. The soft maple swamps are common along the stream, as the fall is very slight here. The valley widens out with a large percentage of the land cultivated, but near the center of the town the stream enters a narrow valley where the sides are steep and the fall is very abrupt. This was once used for water power, but is now owned by the Bridgeport Hydraulic Company, which is protecting the stream as a source of municipal water supply, and eventually plans to reforest its banks. Hemlock is the ultimate type of the slopes and some very good stands are found along the stream at this point. The ridge to the east is oak, or oak and chestnut, but has been culled of the latter species within the past few years. The valley is largely owned by summer residents, and there is good reason to expect that the forest will be improved, both for

the commercial and the aesthetic values it will add to the properties. The lower valley is again more open, with swamp land along the stream and much of the area cultivated. The forests are on the steep slopes at some distance from the stream.

As a whole the Aspetuck valley offers a very favorable opportunity for forest improvement. Planting should follow the removal of the chestnut, not only to increase the growth of merchantable material but also to improve appearances by the introduction of conifers. At present the only break in the broad-leaf forest is the hemlock along the river, which adds greatly to the attractiveness of the road at this point. By scattering rapid growing evergreens throughout the forest the landscape may be made more diversified and more attractive, especially in winter. The rapid growth of pine plantations in this valley is well illustrated on areas just outside of the town to the south.

Redding Ridge Area.

The Ridge extends entirely across the town, dividing the Aspetuck from the Saugatuck drainage. This was one of the earliest settled portions, and contains some of the best of the farming land. This ridge has a relatively uniform elevation, being broad and flat-topped with gradual slopes to the valleys. One of the oldest roads in the town follows it towards Danbury, while the old Newtown-Ridgefield turnpike crossed it at what is now known as Redding Ridge.

The greater part of the original forests were entirely cleared from this section, the present remnant being found as woodlots on the rougher sections. The possibilities of forest management in these woodlots are as good as for the practice of scientific farming on the agricultural lands. At present the woodlots are not being utilized to their capacity. The land occupied is relatively valuable, while the crop produced is of minor quality and quantity. Very little labor would be necessary to convert these stands into a type that would produce a crop in keeping with the rest of the farmlands. There are many small corners in this section that are at present idle but which should be planted for their aesthetic value with financial returns as a secondary consideration.

There extends into the southern portion of the town to the west of the Ridge Road, a more broken area of fairly heavy

woodland. This contains some small pieces of fine timber, although the greater part has been culled. Within this area there are a number of tracts of waste land where the opportunities for reforestation are very good. Some of this idle land is probably agricultural, but does not appear to be needed for the present and should be used for forestry purposes.

While this region is within direct marketing distance of Bridgeport, the cost of hauling wood prohibits its disposal in this manner. The northern part of the region has a market for wood in the lime-kilns, and to a limited extent in Bethel. The greatest use for wood is local in the form of fuel.

Little River Valley Area.

This stream is one of the main branches of the Saugatuck. It crosses the northern boundary of the town east of its center, and flows to the southwest into the Saugatuck near the southern boundary. Its valley is relatively wide, and for the most part agricultural. There are a series of woodlots near the stream, while the slopes are cultivated.

The Putnam Memorial Park at the northern side of the town is of historical interest as it marks the winter camp of a portion of the Continental army during the Revolution. The woodlands of this tract are being improved as park, and the waste land is planted with pine. A small artificial lake at this point is privately owned as a summer camping ground, and the area adjoining it has been planted with pine for the purpose of improving the camp sites in the future. Both of these plantations show good growth.

This valley tends to be swampy, with tree growth of little value. The land will probably be drained at some future time and used for agriculture, but in the meantime the woodlots should be handled on the selection system in order to get the best growth possible, while the small areas of forest soil on the steeper slopes should be planted with conifers in order to bring them into a producing state. Near the lower end there is a sharper gradient, causing the stream to cut through a number of ledges and form a narrow gorge with a series of small falls. The banks are open, or at most covered with brush, giving little indication of the natural beauty of the stream at this point. Small plantings of evergreen trees, such as the spruces or pines,

would make this one of the most attractive places in the town, and would be of great value to the whole community. The cost of such an operation probably would not exceed one hundred dollars, and the future benefits to a town depending on summer residents for much of its income can be readily appreciated.

Gallows Hill Area.

The triangle formed by the Little and Saugatuck rivers with the northern boundary of the town as a base includes the ridge known as Gallows Hill. Redding Center is also located within this area, the broad flat-topped ridge forming some of the best farming land of the town, especially toward the eastern edge of the triangle. The economic changes of the past half century have caused the abandoning of numerous small areas in the western part of the tract which are still unproductive.

In the portion north of the center lies one of the larger forest areas of the town. This forest is very broken in character, due to irregular cuttings. The topography changes as the western edge of the ridge is approached, becoming steeper with more rock outcrop and a larger percentage of true forest soil. The types to be found on this area are extremely variable, but the mixed hardwoods type prevails with a large percentage of oak in the mixture. The chestnut and the oak-chestnut types were once common but chestnut is at present largely eliminated. Maple swamps are common in the depressions.

This area is within the region where cordwood may be handled at a profit, as the haul to the lime-kiln is relatively short. The railroad also is within easy hauling distance, and saw material may be marketed in this manner. At present the tendency in the northern part is to cut clean on a short rotation, while to the south, culling of the stands is the common practice. Intensive forest management is entirely possible here, even under present market conditions, and gives great promise for the future. On the poorer ridge sites, pine should be planted to take the place of the slow growing oak. On the better sites, the selection system in which the best trees are left and the remainder cut for cordwood is recommended, planting the resulting openings with pine. The remaining mixture will then contain only the best of the native species, and will be very productive, since

not only will the mature product be merchantable, but also thinnings and culled material.

South of the center there is not so good a market for cordwood, and intensive management is not so practicable, but the planting of conifers in openings and on waste land would greatly increase the value of the forest in this section. There is at present some good timber, but the greater part of the stand is open and suitable for restocking with conifers. Hemlock increases in abundance near the western side as the Saugatuck is approached, and finally merges into pure stands along the banks of the stream.

Saugatuck Valley Area.

The Saugatuck valley has the form of a question mark with the point of the hook a short distance south of Umpawaug Pond, extending north around Umpawaug Hill and turning southeast to leave the town near the center of the southern boundary. The upper portion of its drainage is characterized by gentle gradients, and swamps are common. The steepest of the slopes are forest soil, but the greater part are cultivated, the forests being mostly of the woodlot type. The mixed hardwood type is most common as the result of the removal of chestnut, but on the rough hill in the northwest corner of the town there are many areas of shallow soil with oak as the dominant tree. With the exception of small isolated stands inaccessible because of the rough character of the topography, the timber of the section has been entirely culled or clearcut. The annual production of the present type is very small, and should be increased by the introduction of pine wherever possible, especially after cutting the merchantable timber. Near the small lake on the western boundary of the town there is a good stand of old hemlock, of value because of its location rather than for lumber. At the north, Umpawaug Hill ends in a rocky outcrop on which the elimination of chestnut, and the burning over of portions by fires originating from the railroad, has resulted in a mixed hardwood type of a more northern character, including hard maple and beech.

Turning south, the stream becomes swifter with a relatively narrow valley, until near the junction with the Little River.

The one exception is at the point where the Newtown-Ridgefield road crosses. Here there are small areas of agricultural land on the slopes and in the valley. The northern end of the valley has mixed hardwood species on the slopes, with some pine near the stream and oak on the ridges. Small areas of maple are common. Below the road the valley narrows for a short distance into what is known as the Glen. The road here has been cut into the hill, as there is only room for the stream in the bottom. Hemlock is the natural type in this section, and the stands add materially to the beauty of stream and road, especially in the summer when the dense shade is very agreeable. Below this the valley widens out into an extensive river meadow, subject to flooding at times. At the lower end of this flat the river passes out of the town over a ledge which, acting as a natural dam, has caused the depositing of sufficient material to produce the meadow conditions above.

This valley as a whole is one in which there is a large percentage of forest land. Its upper portion has the same conditions as the Gallows Hill tract, and the same system of management would apply. Scattering white pines of large size show the possibility of the species in this region. Conditions in the lower portions of the valley are not as favorable for intensive operations, but where they can be carried out without present financial loss, the increased future values of the woodlot would assure a satisfactory profit. In places where chestnut has been cut out, leaving much large timber, conditions are suitable for underplanting with tolerant evergreens such as hemlock and spruce. Other stands that have been cut clear of all merchantable species should be replanted with pine. The natural reproduction of tulip is very good in this region, and should be encouraged. Much of the planting, especially in the northern part, should have the increased beauty of the roads as an object. The effect of evergreen trees on the beauty of the roads is seen in the Glen, and this same effect should be secured in other parts of the valley as soon as possible.

Umpawaug Hill Area.

This section has three distinct parts: the "Seventy Acre" tract, the "Den," and the remainder to the north and east of these which will be called the "Hill" for purposes of description.

The Hill section is largely woodlots, although the Saugatuck Valley forest extends into it at several points on the east. The headwaters of several small streams are within this area, but small swamps are not as abundant as in other sections. The forest as a whole is of mixed species, although small areas of true forest soil are occupied by hemlock or oak. The greater part of the woodlots are on fairly good soil which is not needed for agriculture at present. These stands produce the wood supply of the owners, and on this account are capable of intensive management. Even though a little longer time is required to cut the year's wood, the removal of inferior species only, and the planting of openings in the spring would soon produce increased income from the woodlot.

The area is characterized by a large amount of idle land, much of which is good agricultural soil. The agricultural possibilities of the Hill are apparently as great as of the other ridges in the town, but the area is not so well developed. This is probably due to its being beyond the direct haul to market which has tended to improve other sections of the town. At present there seems to be some indication of increased agricultural activity, with the reclaiming of some waste land. Several plantations of pine have been made which show very good results. The planting of such waste land is perhaps the most important line of forest development at present in this section.

The Den section is only the upper end of a large forest tract that extends into the town from Weston. This tract is along the divide between the Norwalk and the Saugatuck rivers. The relatively level ridge is broken by numerous ledge outcrops, resulting in swamps subject to overflow alternating with rocky ridges. The types vary greatly as to species and value. The ridge type is largely oak which is cut for timber and ties, while the swamp type is maple with a few scattering trees of more value. Towards the eastern side, chestnut becomes more abundant with the increasing depth of soil, especially on the slopes. With the loss of the chestnut, however, this type is changing to the oak or mixed types.

This whole tract, including the portion which is in the town of Weston, should be handled as a unit. There is, however, a fringe of woodlots along the edge that are used by adjoining owners as the source of their wood supply. There are also a

number of areas of waste land that ought to be planted soon in order to produce a crop of timber within a reasonable time. The ridges should also be replanted as the wood is cut off, to increase the annual production of the region.

The Seventy Acre tract is located on the ridge to the north of Georgetown and to the east of Branchville, extending north to a point near Topstone Station. This is perhaps the largest unbroken area of forest soil within the town, and is very favorably located for handling as a small forest unit. The topography is broken, with numerous ledge outcrops and abrupt slopes. The ledges are higher than in the Den section, especially towards the southern end, but they do not prevent all parts of the area being accessible for lumbering. The tract is a divide between the Saugatuck and the Norwalk rivers, with the greater part sloping towards the Norwalk. The railroad follows its western side, and constitutes a serious fire hazard at many points.

The dominant type is the oak ridge with chestnut oak and scarlet oak very abundant. The largest areas of scrub oak are also in this region as the result of repeated burnings by railroad fires. Cuttings have been very irregular. Some of the small swamps apparently have never been cut, as the soft maple and sour gum show virgin conditions. There is a small area of pitch pine on shallow soil at the top of a rocky hill near the railroad where the site is very unfavorable and other species were not so well able to survive. The areas of old field are mostly in the northern end of the area, and are relatively small. Very probably some of these areas will be cultivated again, while other portions will be left to restock with forest trees.

In the development of forestry in European countries, publicly owned forests have played an important part. Forests owned by some of the cities and towns pay the greater part of the expenses of local government. In this country there is a growing tendency toward the purchase of town forests. These are of two classes: one for the protection of the water supply, and the other for the use of the public as parks. In either case there is a definite plan to improve the growing conditions, and realize the greatest income possible. Waste areas are being planted and the forest put in the care of trained men who are carrying out a definite plan of management with an increased future yield as the main object.

The forest area within the Seventy Acre tract amounts to about 1,300 acres, probably one thousand of which will always remain forest. This area is of sufficient size to make a small working unit under management, and is so situated that it could be developed into a very attractive park if owned by the town. Many good camping sites could be provided, and as there is a fair system of woods roads, the development along this line would not be very difficult. A park of this description would not tend to change the character of the forest, except to improve the growing conditions and to protect the area from fire. Much of the growing stock on the area is inferior at present, due to past methods of handling. Because of increased quantity of products, systematic management of the entire area as a unit would permit more economical marketing than is possible at present with a large number of individual owners. Reforestation of the area would be very important, as the species now on the ground are slow growing. Placing this tract of a thousand acres under management with a permanent owner, such as the town, would eventually bring it to its maximum producing capacity. With a rotation of fifty years, pine on an area of this size ought to give an annual yield of at least 700,000 board feet with a stumpage value of about \$7,000, and if cut in a mill also owned by the town, ought to produce an income of at least \$8,000 per annum. A forest of this kind would be of very great value to any town, but especially to one which has a large number of summer residents.

FOREST FIRES.

Protection from fire is absolutely essential to the practice of forestry. During the past fifty years probably no one factor, not even the chestnut blight, has caused so much damage to the forest resources of Connecticut as fire. The loss has not been so apparent, as it has not often been total, but repeated burnings have gradually changed the character of many valuable stands, lowering their quality and value to the vanishing point in some cases.

To prevent this economic loss, a system of fire wardens has been established by the State. The state forester is, *ex officio*, state forest fire warden. The selectmen of each town appoint a

town fire warden, subject to the approval of the state warden. The town warden in turn appoints district wardens in the sections of his town where there is the greatest fire danger. All wardens have power to arrest violators of the forest fire laws, and to summon such assistance as they may need to control forest fires. The cost of this protection is divided between the towns, the counties and the State.

During the progress of this survey, notes were taken as to areas in the town of Redding which showed signs of having been burned over recently. Approximately 670 acres of woodland were estimated as having suffered from fire damage in the past five or six years. Most of this area is in the western part of the town near the railroad. The total number of fires reported to the state fire warden by Redding wardens from 1910 to June, 1915, was thirty-seven, and the total area of woodland burned was estimated to be about 1,500 acres. It is fair to assume that much of this land was burned over more than once, which would account for the difference in the two estimates of area. The lesser amount is nearly ten per cent of the town's forest area, so that the importance of protection is readily apparent.

Of the thirty-seven fires reported, twenty were attributed to railroad causes, three to brush burning, two to general carelessness, one was thought to be incendiary, and the remaining twelve were of unknown cause. For purposes of discussion, the causes of fire may be divided into three classes: malicious fires, careless fires and railroad fires. Even though none of the fires of unknown origin are attributed to railroad causes, it is evident that the latter class is the most serious in Redding. Carelessness of individuals is undoubtedly responsible for most of the fires whose cause is not determined. Malicious or incendiary fires are liable to occur in any community, and can only be guarded against by strict enforcement of the law.

Careless fires are of two kinds. The least numerous are those due to the escape of fires kindled for the legitimate burning of brush, rubbish, etc. In such cases, the carelessness consists in failure to take proper precautions to prevent the spread of the fires, or poor judgment in choosing a time for burning. The remedy is provided by the law which requires written permission from fire wardens for the kindling of such fires during the ordinary dry periods of the spring and fall. This law gives a

warden an opportunity to insist on necessary precautions being taken, and also gives the public an opportunity to coöperate with him in eliminating one possible cause of forest fires. As the best judgment will sometimes fail, however, there will always be danger of fire from this source, and any one through whose carelessness or poor judgment such a fire is allowed to escape, should be held responsible for the expense incurred by the town in extinguishing it.

Other fires of this class are due to carelessness with matches, smoking materials, etc., by pleasure seekers, hunters and fishermen. While occasional fires may be caused by failure to extinguish a camp fire, it is probable that more are due to the carelessness of smokers, either in the woods or on adjoining highways. A large portion of Redding is fairly well protected against such fires, as most of the woodland is closed to hunting or fishing, and the land along the main auto roads is largely cleared. Picnic parties are most frequent along the streams in this region, where the fire danger is relatively slight. Putnam Park, much used for picnic parties, has a permanent watchman who should be able to guard against fires there.

Careless fires can be entirely prevented by thorough enforcement of the laws, and education of the public to the need for care in such matters. This should be the most important duty of a fire warden, but he must have the full coöperation of his fellow citizens in putting into effect such preventive measures as seem necessary. An increased investment in forest plantations throughout the town will result in a demand for greater protection from fire, and owners of plantations will assist wardens in preventing the careless burning of brush or rubbish by irresponsible neighbors.

The railroad fires are due to sparks from locomotive stacks or ash pans and the danger is increased by conditions along the right of way. The necessity of crossing the divide between the Norwalk and the Saugatuck drainage causes an up-grade run halfway across the town for trains in either direction. The greatest danger is in the southern half where the woodland area is more extensive. The broken topography causes many cuts and sharp curves which makes the fire danger greater than in a level country, as the top of the locomotive stack is closer to the level of the ground in a cut, especially if the high bank is

on the inside of the curve. More level, open ground with numerous swamps reduces the fire danger in the northern half of the town, although there are a few spots where fires are frequently set by sparks. Fortunately the highway follows the railroad the greater part of the way, acting as a fire line and making the region readily accessible for fire fighting. The law requires that all steam locomotives must be equipped with effective spark arresters and ash pans. If there is reason to believe at any time that locomotives are in use with defective equipment of this nature, the state fire warden should be informed at once.

The only method of protection employed within the town at present consists in the fire wardens keeping a lookout for fires. When one is seen, a crew is gathered to put it out. The location of wardens for lookout purposes should be carefully considered, as well as the fitness of each one for the work. One who can overlook a large amount of territory may be able to notify other wardens of fires which they can reach more quickly than he can. Where the railroad is the greatest problem there are two methods that should help in solving it. First; clearing up and disposing of all inflammable material to a distance of one hundred feet from the center of the track, leaving the standing trees as screens to prevent the sparks being blown to a greater distance. This can only be done through the coöperation of property owners with the fire wardens and section men, since the railroad company has as yet no authority to do such clearing outside its right of way. Second; patrolling the track after each train during dry seasons. These two measures together would form a control system that should prevent the spreading of railroad fires. Under normal conditions there would probably be very little need of the patrol, but the location of district wardens so as to overlook the railroad right of way would answer the same purpose.

IMPROVEMENT CUTTINGS.

The cultural operations used in intensive forestry consist of a series of cuttings for the improvement of an existing stand in composition, rate of growth, and value of final product. Such cuttings may be grouped in three classes. 1. Cleanings and liberation cuttings to remove undesirable tree growth interfering

with that of greater value. 2. Thinnings to stimulate the rate of growth. 3. Damage cuttings to remove and utilize material damaged by fire, insects, disease, etc. The possible intensiveness of improvement operations depends on the forest conditions and the market for small products such as cordwood.

The life history of a forest stand is the same whether it is of seed or coppice origin. During the first few years each tree is an individual with plenty of room to develop on all sides and above, but soon the side branches begin to be shaded and the tree increases its height growth in order to keep its crown in the open light. The more intolerant the tree, the greater the height growth at this stage. With the development of forest community life, competition becomes keener, and the intolerant trees grow faster in height, overtopping their more tolerant neighbors, while the weaker are suppressed by the more vigorous. The loss in numbers through competition is consequently very great in a natural stand. The shaded side branches die for lack of sufficient light, are eventually broken off and the tree prunes itself naturally.

Clean lumber can thus be secured from a stand which has grown in crowded condition long enough to produce the degree of pruning and height growth necessary. After the trees attain their height growth, the crowding is from the side instead of by overtopping. The loss in numbers is very much smaller now, but breaks due to the loss of mature trees make openings that allow seeding in from nearby trees, thus maintaining trees of all ages in the stand. As the stand is thinned out by nature, the material removed is lost through decay, returning to the soil in the form of humus. This loss in mature trees offsets the growth of the younger ones, so that a natural forest is usually at a standstill so far as production is concerned.

Thinnings are the artificial means used to relieve excessive crowding, and at the same time to save as great an amount of the material grown as possible. Where there are markets so that the owner can even cover expenses, thinnings will pay because of the increased growth of the remaining timber. Light or medium thinnings will save the material usually lost in decay, while the time necessary to grow special-sized material may be shortened considerably, since each tree can be allowed its maximum growing space. Thinnings of existing stands in this region

should remove the weed species and the defective specimens of the crop trees without making an opening greater than can be closed in five to eight years by the crowns of trees left standing. The spacing of the trees on the ground does not necessarily determine the density of the stand, and only an examination of the space occupied by the crowns will tell how much of a break in the crown canopy a given tree will make if removed. The cutting of all undergrowth in a stand is not advisable, as the small shrubs aid in the formation and protection of the humus.

In a large part of the town there is no market for cordwood except for local fuel. When cuttings of any sort are made in such sections, the top wood should be removed if it will at least pay the cost of the operation, as there will be less fire danger and the remaining stand will be in better growing condition. Where this is not possible, the lumbermen should be required to lop the tops, as well as protect the young growth during cutting. Care should be taken in all operations within the forest to protect the fringe of brush and limby trees along the edge next an opening. These trees and shrubs act as a wind break to prevent excessive air circulation within the forest and help to preserve the humus in this manner. The practice of raking up leaves under the forest trees, either for use as a mulch or because near a summer cabin, will tend to cause drying out of the soil. In some cases this change in the soil moisture conditions, and winter damage to the roots not protected by a covering of leaves, will cause the death of forest trees.

In plantations, the cultural operations prior to thinnings are usually confined to cleanings. These consist, in lopping brush and sprouts that are overtopping the planted trees. Only such growth as is directly interfering with them is cut, and then only lopped so as to prevent the rapid growth produced if cut back to the ground, but at the same time freeing the planted trees.

PLANTING.

High labor costs in this country necessitate different methods from those practiced in Europe for the reforestation of abandoned lands, or the changing of species in existing forests. The common method there is to plant seed in more or less cultivated spots, the resulting seedlings being thinned out to the required

number for the area. In this country the seed spot method is seldom used because of cost of labor in preparing, loss of seed by rodents and birds, and injury to the seedlings from excessive competition of other plant growth. Broadcast sowing of seed is also too expensive, as four to ten pounds per acre are required at a cost of \$1.50 to \$6 per pound for seed. Direct planting of nursery stock is cheapest and most satisfactory in the end in this country, as a stand of the species desired is thus established without loss of time and with the proper spacing.

Selection of the proper species for reforestation purposes is limited by the desires of the owner as well as by the site conditions. From a financial standpoint it is further limited to the rapid growing softwoods or conifers because of the value of the crop and the ease of marketing it. Certain special uses may give some of the hardwoods or broad leaf trees local value for reforestation, but their relatively low yield prevents very attractive financial returns. A comparison of the habits of growth of the hardwoods and conifers in the seedling stages, and their relative ease of handling, is all in favor of the conifers. Since seedlings of the latter do not develop deep taproots as rapidly, they are more easily handled in the nursery, and can be shipped greater distances with less loss. After a forest is established the conifers reproduce naturally from seed more readily than do valuable hardwood species, and for this reason are easier to handle by a natural system of regeneration. The conifers are particularly well adapted to growing in pure stands with a large number of stems per acre. Thinnings have merchantable value even though of small size, as much smaller material is sawed with conifers than is possible with hardwoods. Most of the latter grow best in a mixed stand where the cost of protection is highest, and the logging areas necessarily more extended to get sufficient material for profitable marketing, while the conifers can be grown pure with small logging areas.

The planting of conifers in waste areas near roads would be of great value to the town from the aesthetic point of view. The attractiveness of coniferous growth is well illustrated in the Glen, through which many people drive at all seasons because of the absolute contrast with the ordinary hardwood stands. The Glen without the hemlock would be little more attractive than many other stretches of road within the town. A system of

coöperation between adjacent landholders should be developed to secure plantings of sufficient width to make conditions similar to those in the Glen common throughout the town. The cost would be very slight compared with the benefits to the community.

The stock to be used depends on the site to be planted. Where exposed to root competition with other growth, or where the site has unfavorable conditions, better developed stock is necessary than where the forest growth has just been removed or where underplanting is planned. Nursery stock is of two classes, seedlings and transplants. Seedlings are taken directly from the seed-bed and may be either two or three years old. Transplant stock is produced by setting one- or two-year seedlings in nursery rows, and allowing them to grow one or more years there before use for forest planting. Low cost is the only reason for recommending the use of seedling stock of most species. Transplant stock is better able to withstand adverse conditions, and is more commonly used. The cost of stock varies from six to eight dollars for three-year transplants and about half as much for seedlings.

The field work of planting is very simple and a mattock or grub hoe is the only tool required for the work. The average farm laborer can easily set 500 to 800 trees per day, the number depending much on the site conditions. With experienced labor one thousand trees per day per man can be set on good sites. The usual spacing is six by six feet on open land or where there is no established tree growth. Great care should be taken that the roots do not dry out at any time. The total cost of reforestation should not be greater than ten to twenty dollars per acre when transplant stock is used. The time to set forest trees is as soon as the ground is open in the spring. This is often before conditions are fit for other spring planting and the work should be finished before the middle of May. With reasonable care in the planting and handling of stock, the average plantation should have ninety per cent of the trees living at the end of the first year. Broadleaf trees are only handled as one-year seedlings because of their greater seedling growth. Red oak is the easiest handled of the native species but not much used for reforestation as yet. White ash and tulip are sometimes used but it is not always possible to secure stock. In a region where

hardwoods abound, pine or some other coniferous tree should have preference in planting.

White Pine.

This is a native pine and one of the most valuable timber trees of the United States. It is easily managed and of rapid growth, especially for the first fifty to seventy-five years. Although adapted to all sites that are not subject to flooding, it grows best on a fairly moist loamy site. In planting white pine, three-year transplant stock should be used under most conditions as it is most economical and easiest to handle.

White pine has been the most extensively planted tree in the East and several plantations are of sufficient age to show the yields that may be expected. The condition of such plantations in this and other states, and the growth of natural stands, shows that white pine completes its financial rotation in about forty-five to fifty years. That is, the difference between the sale value of the timber, and the total costs of establishing and protecting the stand plus taxes and interest for the period, is greatest at about this age. The amount of timber is then increasing, but not so fast as the interest on the investment. For this reason, if carried too long, the investment costs will consume all the profits, and there will be a loss on the forestation operation, even though the actual sale value of the crop may be much greater than at the time of greatest financial profit. While the amount of timber which may be expected from an acre varies with the site, it will be safe to assume that the average for the town will be at least 35,000 board feet for a fifty-year rotation, and in this report that figure will be used.

White pine has a serious insect enemy and a threatening fungous disease in New England. The insect is a weevil which lays its eggs in the leader in early summer. The larva or grub develops, and tunnels down the inner bark towards the base of the tree. The length of the tunnel is limited only by the length and size of the tree, as sufficient food material is the only desire of the grub. At maturity it bores into the wood and pupates there. The adult beetle emerges from the middle to the last of July. The best method of control is to cut and burn all infested shoots before the beetles emerge, thus reducing the next year's crop of weevils. In this way, damage may be limited to a

slight crook in the tree attacked, since one of the side branches soon takes the place of the leader removed.

The fungus is a blister rust requiring for its alternate host some species of currant or gooseberry and causing the deforming and death of small trees, especially in the seedling stage. It is a European disease which has secured a foothold in this country and will necessitate measures of control to prevent its further spread. Such measures have been undertaken by the State and Federal government, and the use of white pine for reforestation work need not be entirely discontinued. It should be used with discretion, however, and preferably in mixture with some other species.

Red Pine.

Red or Norway pine is a native of the Lake States and Northern New England where it is cut for lumber with the white pine. It will make a good growth on the drier sites but is not as good on moist sites as white pine or spruce. The growth for a short rotation is about the same as that of white pine. The species is free from insect or fungous attacks, and for this reason should be favored over white pine. The quality of the wood is not as high but it is better adapted to use in places where strength is required. As a rule the material can be sold in the same market. It requires somewhat more light than white pine, and is therefore not as well adapted for underplanting unless the cover is removed at an early age. The mixing of red and white pine is perhaps the best method of planting these species in the average conditions found in the town. As with white pine, three-year transplants should be used in most cases.

Scotch Pine.

This is the main timber tree of Europe, and is of very rapid growth on dry unfavorable sites. The quality of the product is not high, being suitable mainly for dimension material and rough boards. With this species the use of two-year seedlings is best, as the seedling growth is so rapid that larger stock is hard to handle.

Norway Spruce.

The planting of this species is increasing in the state, but at present there are no figures available to predict its growth

or yield. It is very extensively used in Europe, and is common here as an ornamental tree, or for wind breaks. Its growth in the juvenile stage is not rapid until after the fifth or sixth year, and the use of stock smaller than three-year transplants is not recommended. It is well adapted for use as a Christmas tree, and may be grown for this purpose in close spaced plantations, either pure or in mixture with pine.

CONCLUSION.

The survey shows that 43.3 per cent of the town, or 8,880 acres, is classified as forest or waste land. This area is divided among the various forest types as follows: 33 per cent is mixed hardwoods, a large part of which is a changing type due to the loss of chestnut; the oak and old field types each occupy 21 per cent; the swamp type 14 per cent; and the oak-chestnut type 8 per cent. The remaining 3 per cent is divided between the hemlock, the chestnut and the pine types. This shows that 64 per cent of the forest area is in types that produce timber, while the swamp and the old field types occupy the remainder. These two types are of small present value because one produces only cordwood, while the other is producing practically nothing.

Although 64 per cent of the forest area may be considered as in a producing state, it is very irregular both as to species and age. The cuttings for the past few years have greatly reduced the amount of merchantable timber still standing. The rotation necessary to produce a merchantable crop is at least forty-five years for the fastest growing of the native species, while the survey shows that only seventeen per cent of the stand is over forty years old. The poor species in the average stand indicates the relatively poor quality of the present forest. The loss of the chestnut has made great changes in the producing capacity of the stands, as it has removed the most rapid growing species. Weed species are spreading into the vacated areas, as they are better able to take advantage of the increase in the growing space than are the more valuable but slower-growing trees. It is safe to say that at present less than half of the growing space is occupied by valuable species.

The rate of growth of the merchantable species remaining is so low that at best they will not produce annually more than

three-fourths of the amount formerly grown. The yield per acre for a fifty-year rotation with the present species, should vary from 10,000 board feet on the best sites to 3,000 on the poorer, but this is much reduced because of the poor stocking of these stands. The average for the town at present is probably under 4,000 feet per acre on a fifty-year rotation, but 4,500 board feet will be taken as the yield in the following comparison. As the area in productive types amounts to 5,675 acres, the yield for a fifty-year period would be 25,540,000 board feet, so that an average annual cut of 510,800 board feet may be assumed. With a stumpage value of six dollars per thousand, this means an annual income of over three thousand dollars from the present forest area on a fifty-year rotation. Under a working plan which provided for 114 acres being cut over each year, such an income might be expected.

The value of cordwood is for local fuel, unless the stand is cut on a shorter rotation with no other product than cordwood. Taken as a whole there is very little sale value in cordwood at the present time, and the returns from this source may be assumed to barely cover the waste of such material due to lack of a market for it in the greater part of the town. The swamp type comes under this classification at present and is not considered here for that reason.

The old field type occupies some 21 per cent of the forest area, or 1,865 acres. This will not all return to forest during the next rotation, as portions will be cultivated, but it is safe to assume that two thirds of this area might be afforested and produce at least one forest crop before being required again for agriculture. This means about 1,250 acres available for afforestation, and which, although as good as the best of the forest land, is not at present producing a crop of any kind. Planted with pine, this 1,250 acres would yield a crop of at least 43,500,000 board feet in fifty years, and probably 50,000,000 board feet would be an underestimate. The area to be cut annually would be only twenty-five acres. Aside from the better quality of the product, this indicates the greater value of conifers as compared with hardwoods for reforestation purposes. If the stumpage value were figured at ten dollars per thousand, the returns from the cut at the end of the fifty-year period would be from \$435,000 to \$500,000, and if this material were milled,

the market value would be well over a million dollars. This represents an annual cut of at least 870,000 feet of timber valued at \$8,700, from an area of twenty-five acres per year.

The gross income from the original forest on a fifty-year rotation figures about twenty-seven dollars per acre, while in the artificially established coniferous forest it should amount to at least \$348. The average value of these forest lands may be assumed to be ten dollars per acre at present, and this may be assumed as a fair average value for the land and growing timber during the past fifty years. This value compounded at five per cent interest for the period equals \$114.67, so that the interest charges are \$104.67 per acre. At an average rate of ten mills, the taxes for fifty years at five per cent compound interest would amount to about twenty-one dollars, so that the interest on the land plus taxes and interest amounts to \$125.67. If the gross sale value of the crop is twenty-seven dollars, a net loss of almost ninety-nine dollars on the crop of timber is sustained on the fifty-year investment. This may be somewhat reduced by the fact that a portion of the cordwood has been used either for fuel or sold in the open market, and that material for repair work on the farm has been cut from time to time. A profit on the land because of increased values might also slightly reduce this loss.

Waste land that is planted would carry an additional charge for the cost of afforestation, that should not average more than ten dollars per acre. On the total investment of twenty dollars per acre, the interest charge at five per cent would be approximately \$220.00 for a period of fifty years. If advantage is taken of the law which provides for the listing of forest land for taxation purposes (Chap. 58, P. A. of 1913), taxes for the period can be calculated on the basis of the present valuation at the ten mill rate. The land taxes with interest would be twenty-one dollars as in the other case, and the stumpage products tax of ten per cent on a yield of \$350 per acre would be thirty-five dollars. The interest charge plus taxes, therefore, amounts to \$276, but as the returns are \$350, the plantations would show a profit of seventy-four dollars per acre. In addition there should be returns from thinnings of merchantable size by the thirtieth year, which would offset the carrying charges to a greater extent than the sale of cordwood will under present forest conditions.

The existing forest does not seem to be much more than paying taxes at present. Interest on the investment in land is entirely overlooked and when a sale is made, the owner of woodland looks on the returns as almost pure gain because he has not expended any actual labor in getting the money. As a matter of fact, the rest of the farm has been obliged to pay not only its own share of the taxes and interest on the valuation of the farm, but the forest's share as well. With proper management, the forest might be made to pay its way without having to depend on the agricultural crops to help it along.

Forestation of the entire forest area, excluding swamp and old field types that may be cleared, would bring some 6,900 acres into pine. The possible annual cut would then be 4,800,000 feet with a sale value of \$48,000, as compared with the present sale value of perhaps \$4,420. Cordwood for local use as fuel could be cut in the form of thinnings, or in the swamp lands too wet for anything but hardwoods. Such a complete change in type could not be accomplished at once, nor is it necessarily desirable. It seems evident, however, that any considerable replacement of slow growing hardwoods by more rapid growing conifers will be an economic gain to the community.

SUMMARY

Redding is an agricultural town increasingly dependent for its tax income on city residents who are turning to the country for permanent or summer homes. Of the total area, 43 per cent is forest or land reverting to forest. This forest area is in very poor producing condition, due to past methods of handling, fire and loss of the most valuable species by disease. The following types are described in the foregoing survey.

Types	Area in Acres.	Per cent. of Forest Land.
Mixed Hardwoods	3000	34
Old Field	1865	21
Oak	1860	21
Swamp	1250	14
Oak-Chestnut	710	8
Hemlock	100	1
Chestnut	70	1
Pine	25	
	8880	100

RECOMMENDATIONS

1.—The forests of Redding have been, and will continue to be, an important factor in its development. The existing forests are not yielding the highest possible returns from the use of the land occupied, and should be managed with a view to increasing the future yield of valuable products.

2.—Weed species should be eliminated and the most valuable species favored in all cuttings. Rapid growing conifers such as white pine, red pine and Norway spruce should be introduced by planting in place of the rapidly disappearing chestnut.

3.—Waste lands not suitable for agricultural crops should be planted with such rapid growing conifers in order that they may become fully productive.

4.—Ornamental plantings along the highways, especially in waste areas at their intersections, will greatly benefit the town by increasing the beauty of its drives. Similar plantings along some of the streams would also be of aesthetic value.

5.—If planting work is planned co-operatively for a week or two early in the spring, more may be accomplished than if individual efforts are depended on. Arbor Day is usually rather late for forest planting, but if roadside and ornamental planting is planned for that day, the school children may be utilized for much of the work.

6.—Absolute protection from fire is most essential if improved forest conditions are to be secured. This involves an active fire warden organization with the full support of the community, and a strong community feeling that forest fires are a cause of economic waste which is unnecessary and can be prevented. Public opinion fully aroused on this subject will insist that every precaution is taken to prevent the starting of fires, and that the forest fire laws are enforced in every case of violation.

TREE SPECIES FOUND IN REDDING.

<i>Acer pennsylvanicum</i>	Striped maple
“ <i>rubrum</i>	Red maple
“ <i>saccharum</i>	Sugar maple
<i>Alnus rugosa</i>	Smooth alder
<i>Amelanchier canadensis</i>	Shad bush
<i>Betula lenta</i>	Black birch
“ <i>lutea</i>	Yellow “
“ <i>papyrifera</i>	White “
“ <i>populifolia</i>	Gray “
<i>Carpinus caroliniana</i>	Hornbeam
<i>Castanea dentata</i>	Chestnut
<i>Cornus florida</i>	Flowering dogwood
* <i>Crataegus</i>	Hawthorns
<i>Fagus grandifolia</i>	American beech
<i>Fraxinus americana</i>	White ash
“ <i>nigra</i>	Black “
“ <i>pennsylvanica</i>	Red “
<i>Hamamelis virginiana</i>	Witch hazel
<i>Hicoria alba</i>	Whiteheart hickory or mockernut
“ <i>glabra</i>	Pignut hickory
“ <i>minima</i>	Bitternut or swamp hickory
“ <i>ovata</i>	Shagbark hickory
<i>Juglans cinerea</i>	Butternut
<i>Juniperus virginiana</i>	Red cedar
<i>Kalmia latifolia</i>	Laurel
<i>Liriodendron tulipifera</i>	Whitewood or tulip tree
<i>Nyssa sylvatica</i>	Pepperidge or sour gum
<i>Ostrya virginiana</i>	Ironwood or hop hornbeam
<i>Pinus rigida</i>	Pitch pine
“ <i>strobus</i>	White “
<i>Platanus occidentalis</i>	Sycamore or buttonball
<i>Populus grandidentata</i>	Largetoothed aspen
“ <i>tremuloides</i>	Quaking “
<i>Prunus serotina</i>	Black cherry
“ <i>virginiana</i>	Choke “
<i>Quercus alba</i>	White oak
“ <i>coccinea</i>	Scarlet “
“ <i>nana</i>	Scrub “
“ <i>palustris</i>	Pin “
“ <i>prinus</i>	Chestnut or rock oak
“ <i>rubra</i>	Red oak
“ <i>velutina</i>	Black or yellow oak

*Rhus	Sumach
Robinia pseudacacia	Black locust
*Salix	Willows
Sassafras sassafras	Sassafras
● Tilia americana	Basswood
Tsuga canadensis	Hemlock
Ulmus americana	White elm
*Viburnum	Viburnum

* Several species.

Connecticut Agricultural Experiment Station

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Control of White Pine Blister Rust in Connecticut 1909-1921

By W. O. FILLEY, Forester and H. W. HICOCK, Assistant

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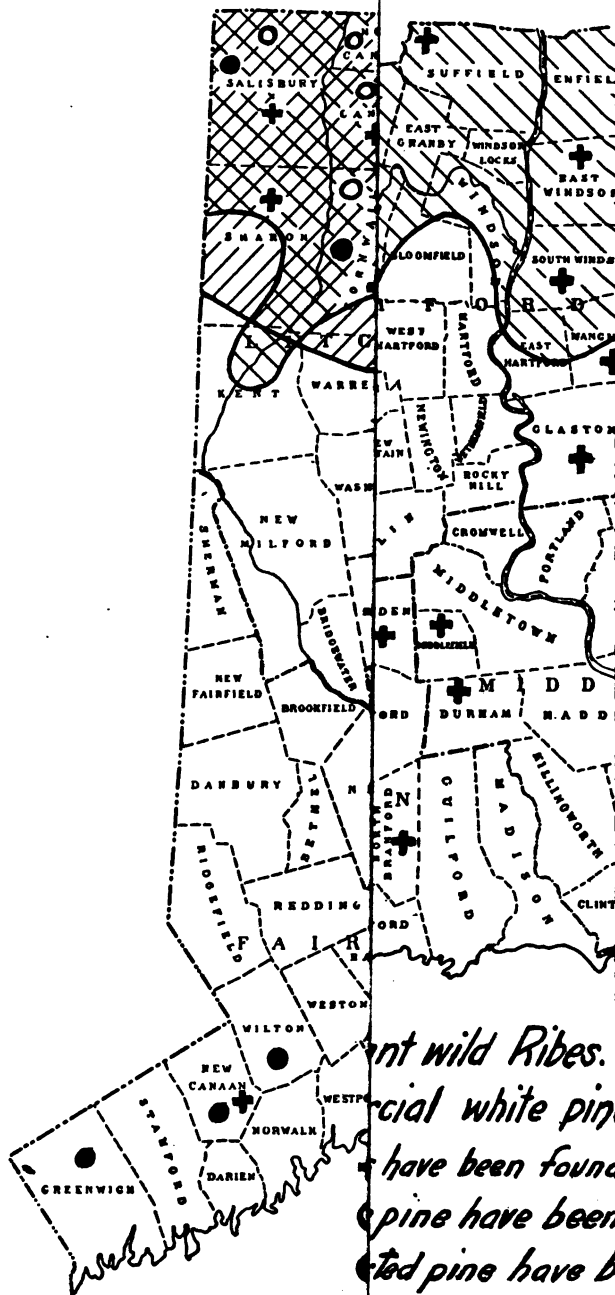
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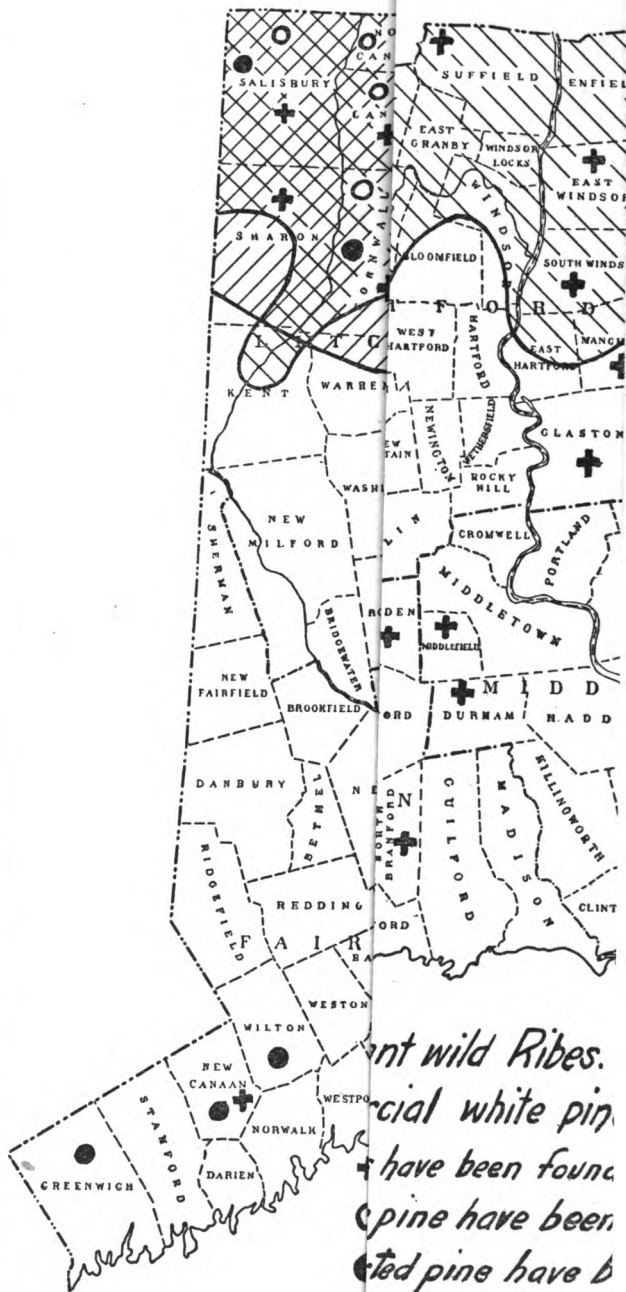
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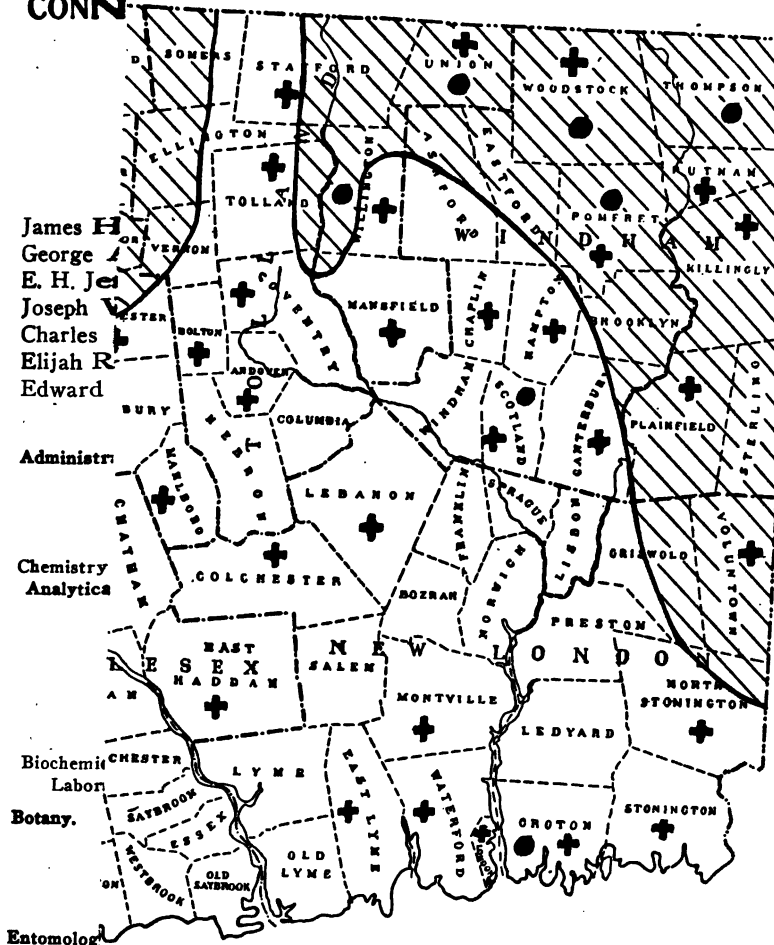
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SURVEY OF WHITE PINE BLISTER RUST CONNECTICUT 1909 - 1921

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Conn. Agr. Exp. Sta.
Office of the Forester
December, 1921.

Control of White Pine Blister Rust in Connecticut

For a number of years it has been evident that the future of the eastern white pine forests depends on the control of a fungous disease known as the white pine blister rust. The purpose of this bulletin is to furnish information regarding this disease, its prevalence in Connecticut, and the practicability of control methods. In order to emphasize the necessity of protecting white pine growth from a very serious menace, a report on the value of white pine timber in the state is included.

In 1916 the rust was found in all the New England States, New York, New Jersey, Pennsylvania, Wisconsin, Minnesota and Ontario, Canada. All these states have taken measures to study and control the disease, and the Connecticut General Assembly of 1917 passed the following legislation for that purpose.

"The director of the Connecticut Agricultural Experiment Station shall have authority to investigate and control the fungous disease known as white pine blister rust or currant rust. Said director may appoint a member or members of the experiment station staff to administer such work under his direction, and may employ other assistance when necessary. All white pine, currants or gooseberries infected with said rust may be uprooted and destroyed forthwith. Said director may designate districts within which currant or gooseberry bushes growing wild, abandoned or escaped from cultivation may be uprooted and destroyed under his direction, and in the performance of his duties, he or any person authorized by him, may at any time enter any public or private grounds, and any person wilfully hindering the performance of such duty shall be fined not less than ten nor more than fifty dollars for each offense. The sum of seven thousand five hundred dollars is appropriated annually for carrying out the provisions of this section." (General Statutes of 1918, Section 2117.)

The discovery of the rust in Connecticut in 1909 resulted in immediate study of its nature and occurrence. This was made by members of the Experiment Station staff, all needed equipment being furnished by the Station. In 1916 it became apparent that active measures for the control of the disease should be undertaken as soon as possible, in addition to a continuation of the studies already begun.

Under an agreement with the Bureau of Plant Industry, United States Department of Agriculture, federal funds for coöperative control work were received in 1916 and have been available each year since. The disease has thus been under observation for twelve years, and for the last six years considerable control work has been done in coöperation with the Federal Government. Under the agreement mentioned the amount of federal funds

expended to September 30, 1921 was \$12,124.44, while the total amount expended by the State was \$24,080.11.

The work of the Experiment Station on the disease has been carried on jointly by the forestry and botanical departments; the former having charge of the administration of funds and of the active control measures, the latter in charge of research and investigations.

The control work has been on an experimental basis for the past six years. The disease develops comparatively slowly and three or more years must elapse before the effects of control are fully apparent. It was necessary to test and compare various field methods to determine which would accomplish the desired results at a minimum cost. Much has been learned regarding the rust and its control. It can now be confidently stated that the eradication of currant and gooseberry bushes to a distance of 1,000 feet from white pine will, in most cases, adequately protect the pine from the disease. The eradication of *Ribes* is practicable, even in regions where the wild species are abundant, and the work can be done by land owners at a comparatively low cost.

A detailed report of studies by Doctors Clinton and McCormick of the botanical department on new points in the life history of the fungus appeared in Bulletin 214 of the Connecticut Agricultural Experiment Station, but in order that the present bulletin may be as complete as possible, a resumé of these studies is included.

The Importance of White Pine.

At the time of settlement of this country by Europeans, the northeastern United States from Maine to Minnesota and from southern Canada to West Virginia (even as far south as Georgia along the mountain tops) contained many virgin stands of eastern white pine (*Pinus strobus*), both pure and in mixture with hardwoods. The forests were valuable to the early settlers only for fuel and for building materials. Implements for working up logs into boards, shingles and framing pieces were comparatively crude, and only trees which could be worked up easily were selected. Chief among these was white pine. Evidence of this is to be found in the older New England houses today. Built almost entirely of white pine except for the frame, and many of them unpainted, these houses have withstood the elements for nearly three hundred years and are still habitable. White pine was therefore one of the first woods to enter into the domestic life of our forefathers and it played an important part in the early development of New England.

The demand for wood in various forms has increased many fold in the last three centuries. For a considerable number of

these uses white pine has been the first choice, as it always will be if obtainable. Many woods have been substituted for it but few have proved as satisfactory. Inroads on the white pine stands by lumbering and fire have been enormous, so that today the annual cut is far less than the demand and is diminishing each year.

From this brief description of the past and present status of white pine, let us glance into the future to see what part this valuable tree is to play in the forest production of northeastern United States, and more specifically of Connecticut.

A plentiful supply of low priced lumber is essential for the prosperity of any community. This is particularly true of an industrial state like Connecticut. The ideal condition would be for every community to produce all the lumber it needs, thus eliminating high freight rates and stimulating local industry. Since this is impracticable in many cases, the question arises as to what species will most fully satisfy the needs of the community and make it most nearly self-supporting.

The killing of the chestnut trees by the bark disease has left the state practically bereft of a good general purpose timber tree. Of the many other native hardwoods, some produce very valuable materials, but few of them can be grown profitably because of the length of time required to mature. It is generally conceded by foresters that while some hardwood lumber is essential and must be produced, the bulk of the lumber in the northeast must come from coniferous trees. Of these, ten species are found growing native within this state as follows: cedars, three species; spruce, one; balsam fir, one; larch, one; hemlock, one; and pines, three. Because of slow growth, restricted range, or other adverse habits all these species except red pine (*Pinus resinosa*) and white pine may be eliminated in considering the future.

These two trees are quite similar in growth and habits, although the wood of red pine is considered to be slightly inferior to that of white pine. Planting stock of both species is easily raised and set out. With regard to immunity to insects and fungi, red pine has a decided advantage and it is less susceptible to damage by fire. White pine is found throughout most of the northern third of the state and if the species is favored, its range may be greatly extended without excessive cost. The range of red pine, on the other hand, covers only portions of the most northerly towns. Its further extension, therefore, must be by planting until the species is more widely established in the state.

Dr. Haven Metcalf of the Bureau of Plant Industry has stated that the practise of forestry in New England and New York is "impossible" without white pine. Perhaps it would be better to say "very difficult." At any rate it is generally conceded that white pine, because of its excellent qualities and many and diversified uses, is our most valuable timber tree. Foresters claim that

it is one of the few trees that can be grown as a crop with profit under intensive management.

If the future of our local lumber supply depends so much on this one species surely it is worth protecting from fire, insects and fungi. Fire is always destructive to growing timber, and white pine is more susceptible than many other species. There are several insects which damage white pine to some extent, but these pests are either not very serious or can be controlled. Of the various fungi parasitic on the tree, the only one which seems to endanger the existence of the species is that with which this report is concerned.

History of the Disease.

This disease is caused by a parasitic fungus known to science as *Cronartium ribicola*. It is classified among fungi as a heteroecious rust because it develops distinct stages of its existence on different host plants, of which it requires two for its development and spread. They are:—

- a. The several species of five needled pines.
- b. The several species of currants and gooseberries.

During a complete life cycle this rust produces four different kinds of spores, two on the pine and two on the *Ribes* host. *Ribes* is the scientific generic name for the plants commonly known as currants and gooseberries, and in this report the term "*Ribes*" is used to designate them.

About 1856 Dietrich, a German botanist, reported the two stages of the fungus on *Ribes* and on pine in northwestern Russia. He evidently did not recognize that he had two forms of the same rust on different hosts. Klebahn of Germany in 1888 was the first to prove the relationship of the two forms when he inoculated leaves of *Ribes* from the spore stage which was found on five needled pines. The fungus has, therefore, been known in Europe by botanists for many years. The five needled pines of the old world are relatively of small commercial importance and it was probably the destruction of the North American five needled pines, introduced extensively for forest and ornamental planting, which really directed the attention of Europeans to the disease.

According to Spaulding's 1911 report,* the blister rust has been found on one or both hosts in Norway, Sweden, Denmark, Russia, Siberia, Austro-Hungary, Italy, Switzerland, Germany, France, Belgium, Holland, England, Scotland and Japan. Losses as high as 100 % have been reported from Europe.

Prof. Tubeuf of Munich wrote a paper in 1905 on the ravages of the disease in Germany on American white pine, a tree which

* Bulletin 206, Bureau of Plant Industry.

has been used there for forest and ornamental purposes for two hundred years. He also cited the damage to nursery stock and young reproduction, and the fact that in some places the use of this species has been abandoned by nurserymen because of the rust.

Moir, after studying the disease in western Europe in 1920, reported* that in Norway, Sweden, Denmark and Belgium the use of white pine in the regeneration of forests had been practically given up because of the rust. Although the necessary control methods are well known there, the cultivated black currant (because its fruit is so highly prized for jam) is considered of more value than the exotic white pine. Moir also studied the effects of the disease on sugar pine (*Pinus lambertiana*), western white pine (*Pinus monticola*) and limber pine (*Pinus flexilis*) planted in western Europe and found all to be as severely damaged as eastern white pine.

It is very difficult to say just when the disease was first introduced into America. Stewart was the first to identify and definitely report it in this country. In 1906 he found a serious infection on various species of *Ribes* at Geneva, N. Y., although it was not until 1912 that it was discovered on white pine in that region. The rust was first reported on white pine in 1909 in several of the eastern states where seedlings imported from Europe had been planted. It is very probable that it had been brought into this country in small quantities for many years previous to 1909 when, as is now known, it was introduced in considerable quantities on forest planting stock, chiefly from Heins Nursery in Germany.

In 1908 and 1909 about 750,000 white pine transplants were imported from Germany for forest planting in Connecticut. After planting it was discovered that some of these trees were breaking out with the yellow blisters, or aecial stage of the rust. It was first discovered in April, 1909 by Mr. C. A. Metzger on trees which he was planting in Wilton, specimens being sent by him to this Station for identification.

From more recent investigations, there are indications that infected pines may have been introduced in at least one place in the state before the general introduction of the rust in 1908 and 1909. At the Bowditch nursery in Pomfret, there is a small forest planting about thirty years old which has developed the disease for a number of years. The trees are known to be of European origin and some of them appear to have been infected prior to 1908.

Life Cycle.

As previously stated, the disease is a rust which requires two hosts (one of the five needled pines and some species of *Ribes*) for

* Bulletin 6, American Plant Pest Committee.

the completion of its life cycle. In describing this cycle, let us assume that we start with a pine which has become infected and is producing spores. These spores (aeciospores) are blown to Ribes leaves in the spring, from early in April until June depending on the season. With proper atmospheric conditions the parasite develops in the leaf and shows on the under side in about two weeks as minute orange-yellow pustules, which mature and break, giving off an orange-colored powdery mass of spores (uredospores). This is the first spore stage on Ribes. These uredospores are capable only of infecting Ribes and during the early part of the summer spread the disease from one bush to another. From midsummer until the leaves fall the second spore stage on Ribes is produced. This takes the form of minute rusty brown hairs (telia) on the lower surface of the leaf. These hairs are made up of single-celled spores (teliospores) which adhere permanently together. Often uredospores and teliospores are both found on the same leaf. The latter upon germination produce minute temporary spores (sporidia) which cannot infect Ribes, but if carried to pine needles may cause infection.

Pines become infected, therefore, only after telia appear on Ribes. Doctors Clinton and McCormick have conclusively demonstrated that the rust enters the pine host through the stomata or breathing pores of the needles and works back into the bark and twig tissues. Needles of the current season are probably more susceptible to infection than older ones.

Once the disease has entered the tree it proceeds to develop parasitic threads (the mycelium) in the tissues of the host. The first outward sign of the work of the parasite is a discoloration of the bark to a yellow or orange-greenish hue accompanied by swelling. In one to several years after infection of its needles the swollen portion of the pine develops what are known as pycnia. These exude on the bark as drops of a sticky fluid containing spores (pycniospores) whose nature in this and other rusts has never been fully determined, but which are considered by some to be spores that have lost their function. When these drops dry out there remain on the bark yellowish spots of varying shape, which later turn a deep reddish brown. They are known as pycnial scars.

Usually during the spring after pycnia are borne the fungus develops the fruiting bodies known as aecia. These never appear until the third year after infection of the pine needles and their development may be delayed until the fourth year, or even longer under adverse conditions. Very small pines are often killed before aecia appear at all. The aecia are the orange spore cases, or blisters, which push through the bark as flattened pustules about one fourth of an inch high. They soon burst and send out a mass of aeciospores which, if carried to Ribes, cause the infection on the leaves mentioned at the beginning of the life cycle. After fruit-

ing, the bark through which the pustules have protruded becomes much seamed and cracked, often exuding pitch and frequently attacked by secondary fungi and insects. Older infections sometimes show constriction with swelling above.

Not infrequently a tree which has been diseased for several years will show a number of distinct zones as follows:—

- a. Dead, cracked bark where the disease has fruited in previous years.
- b. Fruiting pustules, or remnants of pustules, that have fruited during the current season.
- c. Zone of pycnial scars and pycnial drops.
- d. A discolored area usually surrounding all other stages and moving forward slowly into new tissues with each year's growth.

Some important points to be noted are:—

1. Two spore stages are borne on each host during the life cycle of this rust.
2. Two hosts must be present if the disease is to spread from pine to pine.
3. Spores from the stage on pine cannot directly infect other pines.
4. The rust is perennial on the pine but not on the Ribes host.
5. The fungus may grow within the pine host for a number of years without fruiting.

Experiments by members of the Bureau of Plant Industry and others show that all five needled pines are commonly infected by this rust. The botanical department of this Station has made extensive experiments with other pines and a summary of the results appears later in this report. Ribes vary considerably in their susceptibility to infection. Black currants are undoubtedly the most susceptible, followed closely by certain wild gooseberries, skunk currants and cultivated flowering currants. The thick leaved variety of cultivated red currant and certain cultivated gooseberries are probably the least susceptible in this state.

Moist, fairly cool weather is apparently the most favorable for the growth of the fungus and the production of spores. The aeciospores which develop on pine may travel long distances and over large barriers, such as mountain ranges, without losing their quality of infecting Ribes. The average longevity of the spores varies considerably according to their kind. The aeciospores which carry the disease from pine to Ribes may remain alive for several months. Dr. H. H. York has made tests showing that with a humidity of 90 and a temperature of 22-25 degrees C. (72°-77° Fahr.) the sporidia which carry the disease from Ribes to pine remain viable for less than ten minutes.

Legislation.

Under the Plant Quarantine Act of August 21, 1912, as amended March 4, 1917, the Secretary of Agriculture was given the power to "quarantine any state or territory or any district of the United States, or any portion thereof" to prevent "the spread of any plant disease or insect infestation." Under this Act the

Federal Horticultural Board established a quarantine against the shipment of five needled pines and black currants out of the New England States and New York, and against the shipment of these plants from the states east of and including Minnesota, Iowa, Missouri, Arkansas and Louisiana into territory further west. Congress also appropriated \$300,000 for the investigation and control of the disease, part of which was to be used coöperatively to balance money appropriated by the states.

In 1917, the Connecticut legislature passed two laws, which in brief are as follows:—

a. A general plant pest law authorizing the Director of the Connecticut Agricultural Experiment Station to control insects or diseases which are, or may become, serious pests to economic plants. He is given the power to destroy infected plants, prohibit or regulate transportation of the same, and to establish quarantine in such areas and against such pests as he may deem necessary. (G. S. 1918, Section 2106.)

No quarantine against Blister Rust has ever been put into effect in this state.

b. A Blister Rust law authorizing the Director of the Connecticut Agricultural Experiment Station to control the White Pine Blister Rust. He is given the power to order white pines, and currant and gooseberry plants to be unrooted and destroyed. (G. S. 1918, Section 2117.)

This latter act authorizes an expenditure of \$7,500 per year for the control of Blister Rust.

Control 1909-1915.

As was previously stated, 750,000 imported white pine trees were introduced into Connecticut in 1908-1909. Records of their distribution were available at the Experiment Station and soon after the infection on pine was discovered at Wilton by Mr. Metzger in April, 1909, most of the plantations originating from this stock were examined by members of the station staff, and by Drs. Spaulding and Graves representing the Bureau of Plant Industry. In addition to the infection in Wilton, five plantations were found to contain from one to several infections and five others had a few suspicious trees. The above eleven plantations and a number of others were inspected in 1910 and in subsequent years. As no further signs of the rust were found, it was concluded that all the infected trees were either destroyed or had died. The importation of foreign planting stock was discouraged by the forestry department of the Station after 1910. In 1912 one lot of stock received from Holland by a commercial nursery contained so many diseased trees that all were ordered destroyed by the state nursery inspector.

The rust was found on Ribes in Meriden in 1912 and again in 1916. In the summer and fall of 1915, the state nursery inspector

of Massachusetts reported many infections on *Ribes* in that state close to the Connecticut line, and one over the line in the town of North Canaan. Infections reported from other states indicated that the rust had become well established in this country and during the following winter (1915-1916) plans were made for coöperation between the Connecticut Agricultural Experiment Station and the Bureau of Plant Industry for more thorough scouting to determine how serious the infection might be.

Control 1916.

Under this coöperative agreement the salaries of extra men were paid by the Federal Government and their expenses paid by the State. The station forester, then ex-officio state forester, was placed in charge and other station employees were used on the work during all or part of the season. No state funds were available except the appropriation for the care of state forests, a part of which was used. Ten extra men were employed for varying periods from May 1 to September 30.

During May and June two crews inspected eighty plantations and sixteen nurseries where there was reason to think that the disease might exist. Infected trees were found in ten plantations in Wilton, Huntington, Groton, Middlebury, Woodbury, Cornwall, Litchfield (2) and Norfolk (2). Only in Norfolk was there any sign of the disease having spread from its point of introduction, but there numerous secondary infections on native pines were found and destroyed. Wild *Ribes* were very plentiful and on June 15 the first fruiting stage was found on this host. By July 1 it was too late to prevent the spread of the disease from pine and for the rest of the season, using the infected plantations as a center, a crew of six men worked on the eradication of *Ribes*. They removed and destroyed many thousand wild and escaped *Ribes* in an area of approximately three square miles.

In addition, cultivated *Ribes* were inspected over a large territory. It was thus determined that the infected area included about forty-five square miles inside a triangle with its apexes at Canaan Valley, North Colebrook and South Norfolk. Eradication was discontinued in September and several of the men were used to scout the state for *Ribes* infections. During the entire season scouting was done in 110 of the 168 towns. Infections were found in 65, of which only 20 were west of the Connecticut River. The infections in these 20 towns were widely scattered except in northern Litchfield County. In the 45 towns east of the river the infections were more numerous but could not be attributed to any known center of pine infection.

Control 1917.

From the work in 1916 it was apparent that the blister rust had become well established and that special funds would be needed to control the disease. Five thousand dollars was granted by the legislature for immediate use and ten thousand dollars for the two years ending September 30, 1919. The Director of the Experiment Station, being charged with the execution of the law, delegated the direct supervision to the forestry department. The botanical department took charge of the identification of specimens and investigational work.

The labor situation in the spring of 1917 was rather acute, but the early closing of the Connecticut Agricultural College to release students for agricultural work made available a number of men for blister rust control. In all thirty-two men were employed in this work but during the latter part of the summer many of the men left to enter some branch of military service, and for this reason the periods of service varied considerably. As in 1916 the Bureau of Plant Industry coöperated by paying the salaries of extra men employed. The plan of work was as follows:—

- a. Inspection of pine plantations throughout the state.
- b. Scouting for the disease on Ribes.
- c. Eradication of Ribes at Norfolk.

In May and June two crews found infections in eighteen plantations, eight of which had been located in 1916, the remaining ten being found for the first time in 1917. Two plantations and one nursery in which infected pines were found in 1916 seemed to be clean the following year. No infected stock, either pine or Ribes, was found in any nursery in the state, although inspections were made both in the spring and in the fall.

The most serious infection discovered outside of Norfolk was that on the Bowditch estate in Pomfret. Here the infected trees were over twenty years old and had evidently borne the rust for some time, but conditions were not favorable for its spread, as there is almost no native pine in this region and wild Ribes are very scarce.

To facilitate scouting for infection on Ribes, the state was divided into ten districts with a scout for each. These scouts inspected Ribes in yards and along roads in their respective districts once in two weeks and in this way kept track of any new infections that developed. A supervisor of scouts visited each district and spent a day with the scout about twice a month.

The most important result of this scouting was the finding of the pine infection center in Pomfret. Its presence was suspected from the early and general infection of Ribes reported by the scout in that vicinity. By a careful inspection of planted pine he

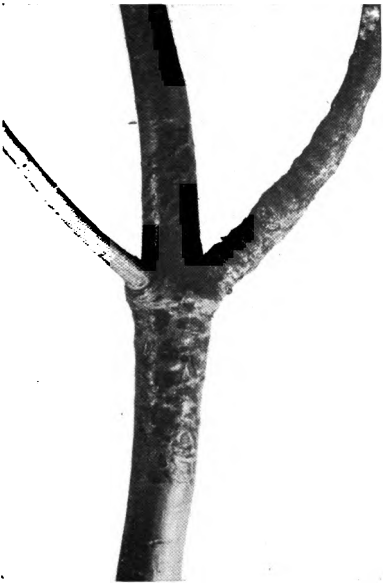
PLATE XXIII.



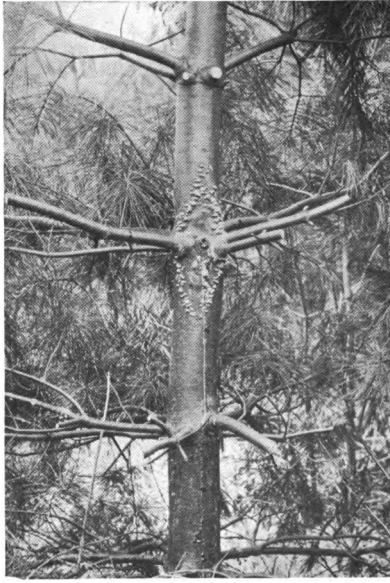
a. Primary infection on imported pine.



b. Telial stage on Ribes.



c. Pycnial stage on pine.



d. Aecial stage on pine.

WHITE PINE BLISTER RUST.

PLATE XXIV.

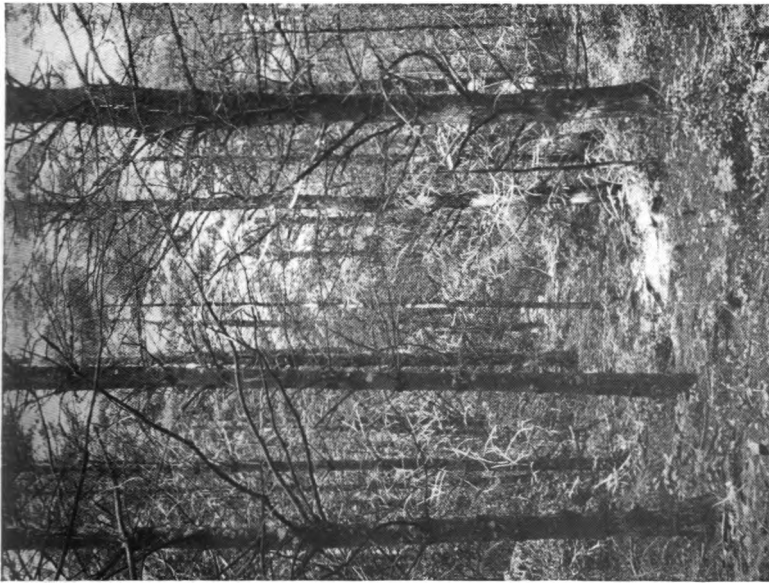


a. Natural reproduction in Cornwall.



b. Plantations in Middlebury.

FUTURE WHITE PINE FOREST.



a. Natural stand unthinned.



b. Natural stand thinned.

YOUNG WHITE PINE FOREST IN UNION.

PLATE XXVI.



150 years old; 140 feet tall; 67,000 bd. ft. per acre.

MATURE WHITE PINE FOREST IN CORNWALL.

was able to locate a center of infection on the Bowditch estate. The Ribes infections in other parts of the state, with one exception, were too scattering to indicate infection centers close at hand. The exception was in the vicinity of Branford where there seemed reason to suspect the presence of pine infection, but a careful search failed to show any.

Control work was again confined to the Norfolk region, for nowhere else was there evidence that the disease had spread to pines outside the infection center. The control areas selected covered about ten square miles in the northern half of the town. Work with two crews was begun May 12th and another was organized in July. Early in the season an attempt was made to locate and remove pine infections on those areas from which Ribes was eradicated the previous year. Six hundred acres were covered in this way but the work was slow and expensive. The average cost of \$1.80 per acre did not seem justified when compared with the much lower cost of removing Ribes the previous year. Moreover, it is never possible to detect with certainty all pine infections, since some of them may be so well hidden as to be overlooked, while others may not be sufficiently developed to be recognizable.

Systematic scouting for pine infection was therefore abandoned and during the rest of the season Ribes were eradicated from about three thousand acres at an average cost of 85 cents per acre. While no accurate count was kept of the Ribes removed, the number varied from many thousand per acre in some of the swamps to almost none on the hardwood ridges. The cost naturally varied with the character of the land and the abundance of Ribes. From 50% to 60% of all Ribes destroyed showed infection.

Infection on Ribes was found to be fairly general, not only in the control area but for some distance east and west in the towns of Colebrook and Canaan. The various species of Ribes found in the order of abundance were as follows:—*Cynosbati* var. *glabratum*, *oxyacanthoides*, *vulgare*, *prostratum*, *nigrum*, *odoratum*, *Cynosbati*, *rotundifolium*, *gracile*, *triste* var. *albinervium*, and *Americanum*.

Control 1918.

On account of war conditions which prevailed in 1918 practically no eradication work was attempted. Members of the Station staff inspected pine and Ribes in different parts of the state throughout the summer. Two extra men were employed in Norfolk to check over areas previously worked, with gratifying results. On one and one-half square miles of territory worked in 1917 only 386 Ribes were found, or about one for each two acres.

From May 1 to September 1 selected red and black currant bushes were sprayed at ten day intervals with 4-4-50 Bordeaux mixture to determine the possibility of controlling the disease on Ribes by spraying. Unsprayed bushes were used as checks. The results indicated that it might be possible to hold the disease in check on Ribes by frequent spraying, but that the frequency required would make the plan impracticable.

As previously mentioned, infections on cultivated Ribes found in the town of Branford in 1916 aroused the suspicion of a pine infection nearby. Infected Ribes were plentiful at three places and at two of these all bushes were destroyed soon after discovery. The black currant bushes at the remaining place were inspected at frequent intervals, as were the few pines in the neighborhood, but without result. The nearest known pine infection was at Middlebury, some thirty miles away. In September 1918 an intensive survey was made of all cultivated Ribes within three miles of the infected black currants. Of 201 places visited 73 had Ribes and infection was found at 13, but the infections were too widely scattered to indicate the presence of a pine infection center.

Nine plantations and one nursery were inspected in 1918. In six plantations fruiting infections were found, while in two others there were specimens apparently killed by the rust. One new infection was found in the town of Greenwich in a plantation which had not previously been inspected.

During the summer practically all the scattered Ribes infections located in 1917 were visited at least once. A decrease in the number of infections was evident as compared with the previous year. Considerable time was spent in July and August inspecting Ribes in the southwest corner of the state, but infections were not sufficiently abundant to indicate the presence of unknown pine infections.

Control 1919.

From inspections in previous years it was apparent that many of the plantations of imported pine were in no danger from the rust, and these were consequently eliminated from the inspection of 1919. Six plantations were inspected and the disease was found in five, but only in small amounts and with no indication that it was spreading.

Eradication of Ribes was resumed May 1 on areas in Norfolk and Colebrook adjoining those worked in 1917. During the summer a crew of five men covered about 2,500 acres and destroyed 30,000 wild Ribes bushes. The cost of eradication averaged 93 cents per acre, including wages, sustenance, supervision, transportation and depreciation of equipment.

Checks were made to determine the efficiency of the crew in

eradicating Ribes. Four tracts worked earlier in the season were selected and a portion of each reworked. The results showed that the crew removed an average of 90% of all Ribes during the first working of the ground.

During June scouting for infection on cultivated Ribes in 24 towns in Tolland, Windham and New London Counties showed infection in four towns, but only at places where it had been found in previous years. Later in the summer nine towns in Litchfield County were scouted in the same manner and Ribes infection was found to be quite general.

The survey of the Branford area which was made in 1918 (see page 316) was checked up in 1919. All but two places showing infection on Ribes in 1918 showed it in 1919, and one new infection was found. All white pines in the area were inspected for infections but none found.

In order to determine the spread of the disease in Pomfret, a survey covering about 30 square miles adjoining the Bowditch estate was made in July and August, 1919. All pine plantations and cultivated Ribes in the region were inspected and mapped. Eighteen separate infections on Ribes were found, but no pine infection except at the Bowditch estate. Here the scout eradicated a large number of escaped Ribes bushes in and near the pine grove. Wild Ribes are very scarce in this vicinity.

In coöperation with the Bureau of Plant Industry, a pine survey of the state was begun in December, 1919. Its purpose was to obtain information regarding the amount and value of white pine in the state and to demonstrate the importance of protecting it from the rust. One man was employed until June, 1920, mapping the pine lands of Windham, New London and eastern Tolland Counties, reporting on the age, area, percentage of pine in mixture, quantity in board feet and value of all stands containing pine.

Control 1920.

Labor suitable for this work was difficult to obtain until after the schools and colleges closed, when twelve men were secured and put in the field. The area selected for eradication consisted of about 2,000 acres in the town of Colebrook, east of that eradicated in 1919. Forty three thousand Ribes bushes were removed and destroyed. Checks run frequently, according to methods prescribed by the Bureau of Plant Industry, showed that the men were getting 90% to 97% of all Ribes during the first trip over the ground.

As in former years inspection of cultivated Ribes was carried out to determine the approximate limits of the disease. In 1920 this work was confined to Litchfield County where infection on Ribes was found to be quite general. No attempt was made to

check over either the Branford or the Pomfret areas during the season, nor was there any inspection of plantations.

Work on the pine survey, started in 1919, was resumed in November, 1920 and a new line of work, the scouting of native white pine for infection, undertaken. This seemed necessary because of the amount of *Ribes* infection found throughout the state for a number of years. The Bureau of Plant Industry furnished one man for the survey and two for the scouting. The two lines of work were carried on simultaneously, as this method was considered more efficient than to cover the ground twice for mapping and scouting. The cost of the survey was 2 cents per acre for the area actually mapped and about 3 mills per acre for the entire area covered. The men located infections on native pine in the towns of Cornwall, Barkhamsted, and North Canaan, as well as many new infections in Norfolk and Colebrook. (For results of the survey see page 321.)

Owing to the fact that infection had been found on *Ribes* in the vicinity of Branford for a number of years, this region was again scouted for infections on pine previous to the start of the regular scouting and survey work. All pines, both native and ornamental, in the neighborhood of known *Ribes* infections were carefully looked over, but not a single pine infection was found.

Control 1921.

Beginning on April 14 seven plantations and one nursery were inspected for pine infection. One plantation contained several fruiting specimens of the rust and in another two suspected trees were removed. In the remaining plantations and in the nursery, no sign of rust was found.

A crew of five men organized a camp in Norfolk on May 1 and carried on eradication, scouting and checking until September 15. Some 8,000 acres in the towns of Norfolk, Colebrook and North Canaan were covered and 39,000 *Ribes* bushes were removed and destroyed. Of this area, 4,000 acres was new territory which had not been previously worked. In addition the crew scouted forest and ornamental plantings of imported stock in Litchfield, Cornwall, Norfolk and Colebrook and found infections in all plantations thus inspected.

The effectiveness of *Ribes* eradication cannot be determined until sufficient time has elapsed to allow *Ribes* grown from seed, or from incompletely removed root crowns, to become large enough so that they can be readily seen. Furthermore, on pines which have become infected since the *Ribes* were removed, the disease would require at least two years to reach a stage which could be unmistakably recognized. In order, therefore, to check up the results of previous *Ribes* eradication in Norfolk, some 4,000 acres

which were worked in 1916, 1917 and 1919 were reworked in 1921 with the following results:

a. Some large *Ribes* missed in previous years were found, but these were so few in number per acre as to be of minor importance. Numerous small *Ribes*, originating either from seed or from improperly removed root crowns were found, but the small amount of leaf surface and the fact that these plants were usually growing under dense shade reduces the liability of their acting as transmitters of the disease for several years. Judged by the comparatively small number of *Ribes* found in reworking, the first eradication appears to have been fairly effective but the necessity for rescouting these areas after a few years, and reworking them if necessary, is indicated.

b. The number of pines showing infection which had occurred since eradication was almost negligible. In contrast with this, on an area from which *Ribes* had not been removed prior to 1921, twenty-seven pine infections were found, 70% of which took place in 1918 and 1919.

During the winter of 1920 and 1921 scouts had discovered new infections on native pine in several additional towns in Litchfield County. Prior to this time, the only known infection on native pine was in the Norfolk-Colebrook region. Careful investigation of these newly located infections indicated that control must be undertaken on a much larger scale. It was considered advisable, however, to secure further information as a basis for future work in the new areas. During the summer and fall, therefore, a preliminary survey of the towns of Cornwall, Canaan, Salisbury and a part of North Canaan was completed. The towns were subdivided into blocks for each of which observations were made on the prevalence of *Ribes*, amount and character of pine infection, and other factors bearing on control. Pine infection was found to be quite generally distributed over all the territory scouted and in some places it was very heavy. *Ribes* were plentiful but not as abundant as in the Norfolk region.

During November a scout covered practically all the towns along the Rhode Island line inspecting native pine but was unable to locate any infection.

The survey made in Pomfret in 1919 was checked up this year. Four fruiting infections on pine were found at the Bowditch estate and one new infection on ornamental pine about one-half mile to the south. The cultivated *Ribes* scouted in 1919 showed less infection in 1921 than in the former year.

On July 1, 1921 the federal allotment for blister rust control in Connecticut was cut from \$5,000 to \$2,000. Moreover the Secretary of Agriculture ruled that this allotment should be used for education, demonstration and supervision, but not for eradication as in previous years. The federal money has therefore been used

since July 1 to pay part of the salary of a member of the Experiment Station staff whose time is largely spent in supervising the control work. As a result of this reduction in the federal funds available, the amount of control work which can be done with the present state appropriation is greatly reduced. Moreover the disease has recently been found in alarming amounts in several new sections. To check its spread, prompt action is necessary, or much young pine will be killed before reaching merchantable size. It is imperative, therefore, that owners of pine coöperate in the control work, since state and federal funds are wholly inadequate to care for the present situation.

Future Control Work.

Blister rust control has been in the experimental stage during the past six years. Although its principles were well understood in European countries they had never been practiced extensively there, and many points in the life history of the disease were not thoroughly understood. Its characteristics and life history are now well known as a result of the exhaustive studies which have been made in this country by federal and state agents. There are still many scientific points not fully understood and investigational studies must be continued, but the practicability of control methods has been firmly established. The coöperative work with the Bureau of Plant Industry in the various states has demonstrated that the application of simple field methods at a moderate cost per acre will hold the disease absolutely in check.

These control methods should be carried out locally by pine owners themselves, since they are the ones directly benefited by the results secured. Public funds should be used for supervision, for education and for further experimental work, but not, as in the past, for actual field control on a large scale. Education of pine owners through state and federal agencies is essential, because many of them do not realize the value of their young pine or the necessity of protecting it from the rust.

On average quality forest soil which could not profitably be used for agriculture, white pine either self-sown or planted will, in 40 to 50 years, produce a gross revenue of over \$200 per acre, as contrasted with \$75 per acre if the land grows only hardwoods. Unless the blister rust is kept under control, however, it may and probably will, destroy the pine before it reaches merchantable size, as the greatest danger is to trees less than 15 feet high to which the disease is fatal in a very few years.

Assistance must be given pine owners in recognizing the disease, for its presence on pine is very deceptive. It can be identified at the end of the first year only with the aid of a microscope. After the second year a careful scrutiny will reveal its presence,

although to an untrained eye a tree already diseased beyond recovery may outwardly seem to be healthy.

Supervision of Ribes eradication by state or federal agents is of great importance. Unless the work is done with sufficient thoroughness to remove practically all the Ribes in the vicinity of pine stands, the protection secured will not be sufficient to warrant the expense incurred. A trained supervisor will be able to maintain the efficiency of the work and to reduce its cost by eliminating areas where Ribes are not sufficiently abundant to require eradication.

The National Situation.

The introduction of this disease into the United States and its subsequent spread has brought about a condition very different from that in Europe. Our eastern white pine, sugar pine, limber pine and western white pine were formerly used quite extensively in western Europe for forest and ornamental planting. On account of damage by the blister rust the use of these trees is now being discontinued because the cultivated black currant is more highly prized for its fruit than the American soft pines for their lumber. In this country the necessity for protecting the five needled pines at the expense of Ribes should be beyond question, because of the greater importance and value of pine lumber as compared with currants and gooseberries.

In the northeastern United States where the rust was generally introduced some twelve years ago the disease, on account of its deceptive character, became firmly established before the damage it might do was generally realized. In many parts of the range of the eastern white pine, 10% to 15% of all the trees of this species are infected and in some areas infection runs as high as 100%. This condition is very serious because much of the present crop of young pine will be killed before it is large enough to cut and because, if the rust is not controlled in the immediate future, it may become so prevalent as to render the use of white pine impossible in the regeneration of our forests.

In Connecticut the situation is not as bad as in other New England states, because the area in which blister rust can become serious is limited to about 500 square miles in northern Litchfield County. This is the only section of the state where wild Ribes are abundant. It is very probable that infection will occur at many other points because of the presence of cultivated Ribes, but it is believed that such infections will be quite local and easily controlled.

In the western states the danger from blister rust is one of the future rather than of the present. Agents of the Bureau of Plant Industry are constantly on the watch for its appearance and every

possible means of enforcing the quarantine against the shipment of *Ribes* and five needled pines into the west are being used. Very recently (November 1921) an infection on eastern white pine planted in southern British Columbia has been discovered, and since that time several infections on western white pine have been found over the line in the state of Washington. However, these infections have apparently been located before the disease has spread to any extent, and with sufficient funds it should be possible to control it. Nevertheless, the danger of its becoming established in the west is very great. A strict enforcement of the federal quarantine and continued vigilance on the part of federal scouts will be necessary to prevent its introduction and spread into a region where control may prove impossible.

The territory between British Columbia and Mexico includes the range of the western white pine and sugar pine which are very important timber trees. Several other five needled species found in this section, while valuable to some extent for lumber, are even more valuable as a covering for high mountain water-sheds. Moreover, there are more than 60 species of *Ribes* native to this region. This combination of several species of pine susceptible to the rust and an extraordinarily large number of *Ribes* species affords ideal conditions for the development and spread of the disease throughout the entire range of the western five needled pines.

NEW INVESTIGATIONS BY THE BOTANICAL DEPARTMENT.

Though the general life history of the blister rust had previously been worked out in Europe there were some lesser phases, unknown or in doubt, when the botanical investigations were first undertaken by Doctors Clinton and McCormick of this Station. The life history in general has been covered by their work, but special emphasis was laid upon the doubtful or unknown points. A part of these investigations have been published in Bulletin 214 (pp. 428-459) of this Station, and in papers read before the Blister Rust Conferences and the Botanical Society of America. Additional details will be given in a bulletin of the Station to be published during 1922.

The main new points brought out in their investigations were along two lines. First, as regards the point of entrance of the fungus in the pine, it was shown by artificial infections that this takes place through the leaves, and that a very definite method is followed. The germinating sporidia gain entry by a germ tube through the stomates, or breathing pores, into the interior of the

leaf and immediately form an enlargement which may have several functions, such as a hold fast, storehouse for food, etc. From this swelling an infection thread proceeds through the stomatal cavity and comes in contact with the leaf cells. A tube is sent into the cell for food, and then a vigorous growth of threads results in the intercellular spaces, in time forming a sclerotial mass of fungous threads. This development kills the green coloring matter of the cells, with the result that a golden-yellow spot shows on the leaf near the spot where the fungus entered. In time the fungous threads come in contact with the food carrying ducts of the leaf, and then in an inconspicuous manner rapidly work lengthwise of the leaf, especially downward, until they reach the bark, where a vigorous development takes place resulting in the swelling already noted. These facts have all been confirmed by similar observations on infections taking place in nature. While natural infection of the leaves takes place in the fall, the external evidence, through the golden yellow spots on the leaves, is not conspicuous until the following spring or early summer.

The second point brought out was that not only the five needled pines but also seedlings of certain two and three needled pines could be artificially infected, some as readily and vigorously as the white pine. On some of these hosts the infection has proceeded as far as any that has taken place in infection work at this Station with white pine of the same age: namely, to where the infected stems produced the pycnial stage. Altogether some thirty different species of seedlings of the genus *Pinus* have been experimented with, and at least fifteen of these have become infected in the leaves. The varying vigor of the rust's development indicates difference in resistance of the species inoculated, so that no doubt with certain of them infection proceeds no further than invasion of the leaf, and so fails of true infection.

As regards infection of *Ribes* with the aeciopores from white pine, successful inoculations have been made with twenty-six species. Some species show much more resistance to infection than do others, cultivated black currants being one of the most susceptible.

A SURVEY OF WHITE PINE IN CONNECTICUT.

The pine survey for Connecticut, which was made during the winters of 1919-1920 and 1920-1921, has been briefly referred to in other parts of this report. The object of the work was to furnish data on the amount and location of white pine growing within the state. As such figures would manifestly not be accurate for any extended period, it was decided to accomplish the work at as low a cost as possible consistent with reasonable accuracy.

Since there is no considerable amount of white pine outside of Litchfield, Hartford, Tolland, Windham and New London Counties, the survey was limited to such portions of these counties as were known to contain pine.

The U. S. G. S. topographic sheets were used for the mapping. With the aid of a pocket compass and pacing, the boundaries of the various blocks of pine were sketched in. Three general types were plotted upon the map.

a. Pine reproduction; stands under 25 years of age with pine forming 60% or more of the mixture.

b. Pure pine; stands over 25 years of age with pine forming 60% or more of the mixture.

c. Pine-hardwoods; mixed stands with other species forming more than 40% of the mixture.

The country was divided into blocks with the highways as boundaries and further subdivided into the various types, for each of which notes were made showing:—

- | | |
|------------------------|-----------------------------------|
| a. Age class. | c. Area in acres. |
| b. Percentage of pine. | d. Volume in board feet per acre. |

Areas were obtained by scaling the map. Age was roughly determined by counting the whorls of branches. The estimates of percentage and value were, of necessity, made largely by eye but were checked by the frequent laying out of plots on which more careful estimates were made. In practically all cases supplemental notes regarding the character of the timber, reproduction, etc., were kept for each type.

From field data thus gathered it was possible to compile figures on area of reproduction, area of pure pine, area of pine in mixture with other species and the stand in board feet for each town surveyed. Figures of total forest area were taken from the Forest Survey of Connecticut, published in the annual report of this Station for 1915. Fifty-two towns were covered in whole or in part. A summary of the information for each county by towns follows.

HARTFORD COUNTY.

Town	Pure Pine Reproduction Acres	Pure Pine Acres	Pine-Hard- woods Acres	Forest Area Acres	Stand of Pine B. F.
Avon	686	445	110	7,400	1,260,000
Bloomfield	34	38	20	4,350	430,000
Canton	127	479	78	11,600	370,000
E. Granby	386	198	..	4,300	240,000
E. Hartford	35	123	..	2,100	800,000
E. Windsor	16	77	125	3,400	450,000
Enfield	832	765	424	7,000	6,760,000
Farmington	500	70	...	8,000	710,000
Granby	888	923	1,446	17,000	5,550,000
Hartland	108	9	613	15,700	350,000
Manchester	84	212	45	5,700	1,650,000
Simsbury	1,216	1,252	150	10,500	8,830,000
S. Windsor	12	92	145	4,800	990,000
Suffield	215	203	115	5,450	450,000
Windsor	30	455	352	7,300	4,210,000
Windsor Locks	685	271	...	2,550	890,000
Totals	5,854	5,612	3,623	117,150	33,940,000

LITCHFIELD COUNTY.

Town	Pure Pine Reproduction Acres	Pure Pine Acres	Pine-Hard- woods Acres	Forest Area Acres	Stand of Pine B. F.
Barkhamsted	1,129	336	3,141	15,300	5,480,000
Canaan	157	333	9,587	15,500	1,372,000
Colebrook	1,211	964	8,613	15,400	6,120,000
Cornwall	700	444	803	18,100	6,920,000
Goshen	20	133	192	15,100	2,040,000
Harwinton	75	36	150	11,700	340,000
Litchfield	35	67	73	16,000	780,000
Morris	28	6	40	3,550	130,000
New Hartford	781	257	1,092	13,000	2,250,000
Norfolk	835	1,437	10,394	22,300	12,100,000
North Canaan	768	889	3,928	5,850	1,980,000
Salisbury	496	1,424	6,581	17,800	10,420,000
Sharon	...	42	862	17,000	310,000
Thomaston	...	3	30	4,550	60,000
Torrington	46	154	55	16,200	680,000
Winchester	433	185	2,813	12,700	1,400,000
Totals	6,714	6,710	48,354	220,050	52,382,000

NEW LONDON COUNTY.

Town	Pure Pine Reproduction Acres	Pure Pine Acres	Pine-Hard- woods Acres	Forest Area Acres	Stand of Pine B. F.
Griswold	25	5	725	9,450	40,000
Voluntown	250	437	8,812	22,500	4,910,000
Totals	275	442	9,537	31,950	4,950,000

TOLLAND COUNTY.

Town	Pure Pine Reproduction Acres	Pure Pine Acres	Pine-Hard- woods Acres	Forest Area Acres	Stand of Pine B. F.
Ellington	20	40	20	11,300	90,000
Mansfield	..	3	..	12,600	35,000
Somers	392	424	280	9,000	1,800,000
Stafford	38	447	5,341	28,800	2,980,000
Tolland	20	58	89	16,500	250,000
Union	1,000	1,594	9,831	15,000	15,920,000
Willington	73	32	145	15,900	250,000
Totals	1,543	2,598	15,706	109,100	21,325,000

WINDHAM COUNTY.

Town	Pure Pine Reproduction Acres	Pure Pine Acres	Pine-Hard- woods Acres	Forest Area Acres	Stand of Pine B. F.
Ashford	..	342	3,093	14,600	1,590,000
Brooklyn	75	69	1,770	7,500	320,000
Canterbury	..	87	932	12,800	400,000
Eastford	150	417	3,261	13,100	4,720,000
Killingly	200	274	11,556	19,100	1,020,000
Plainfield	50	36	1,873	13,000	160,000
Pomfret	100	42	2,775	12,500	440,000
Putnam	100	409	3,495	5,550	1,290,000
Sterling	50	30	4,210	13,000	300,000
Thompson	400	672	11,760	16,400	2,480,000
Woodstock	600	1,352	11,836	19,800	10,050,000
Totals	1,725	3,730	56,561	147,950	22,770,000

TOTALS BY COUNTIES.

County	Pure Pine Reproduction Acres	Pure Pine Acres	Pine-Hard- woods Acres	Forest Area Acres	Stand of Pine B. F.
Hartford	5,854	5,612	3,623	117,150	33,940,000
Litchfield	6,714	6,710	48,354	220,050	52,382,000
New London	275	442	9,537	31,950	4,950,000
Tolland	1,543	2,598	15,706	109,100	21,325,000
Windham	1,725	3,730	56,561	147,950	22,770,000
Totals	16,111	19,092	133,781	626,200	135,367,000

In the remaining 117 towns there are scattered plantations and native stands of white pine which should be included in totals for the state. The following figures are therefore thought to be conservative.

	Pure Pine Reproduction Acres	Pure Pine Acres	Pine-Hard- Woods. Acres	Forest Area Acres	Stand of Pine B. F.
State of Connecticut	20,000	20,000	150,000	1,483,300	150,000,000

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JANUARY, 1924

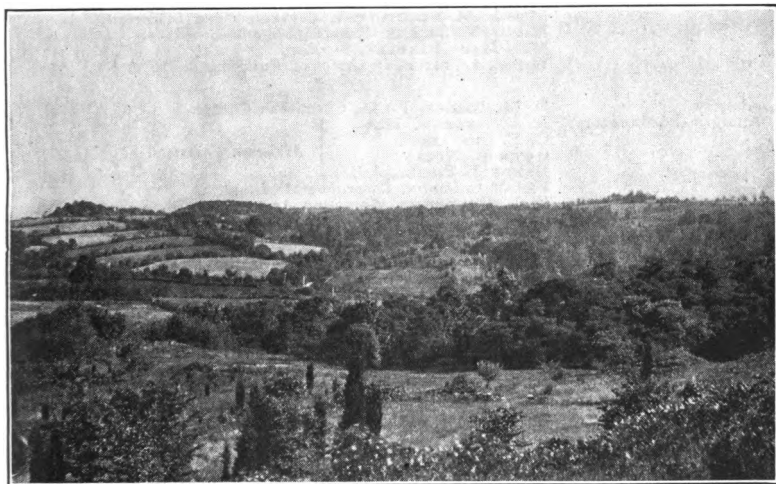
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CONNECTICUT AGRICULTURAL EXPERIMENT STATION

NEW HAVEN, CONN.

Better Forests for Connecticut

HENRY W. HICOCK



The Woodlot is a Farm Problem

Forestry Publication No. 14

The Bulletins of this Station are mailed free to citizens of Connecticut who apply for them, and to other applicants as far as the editions permit.

CONNECTICUT AGRICULTURAL EXPERIMENT STATION

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January, 1924

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PRACTICAL SUGGESTIONS TO THE WOODLOT OWNER.

Plant idle or waste land with fast growing coniferous or soft-wood trees.

Improve inferior stands of young hardwoods by planting 300 to 500 coniferous trees per acre.

Improve the better hardwood stands by thinnings, so that cord-wood and other low grade material may be by-products of the forest and the more valuable species may be left to grow to saw-log size.

Develop better methods for selling and utilizing woodlot products.

Change the present inequitable method of forest taxation which forces the forest crop to bear an annual tax thus lowering the net returns so that growing timber is often unprofitable.

Work for better protection from fire and other enemies of the forest.

Harvest the minor products of the forest, thus getting several crops from the same area.

THE FORESTRY SITUATION IN CONNECTICUT.

Use of Forest Products.

*Annual consumption of sawed lumber..	350,000,000 Bd. Ft.
*Annual production of sawed lumber....	65,000,000 Bd. Ft.
Ratio of consumption to production.....	5 to 1

The Forests of the State.

†Total land area of the state.....	3,085,000 acres.
Land in forest or suitable only for forest (estimated) at least.....	1,500,000 acres.
*Present annual production.....	65,000,000 Bd. Ft.
Annual per acre production on a basis of 1,500,000 acres.....	40 Bd. Ft.
Minimum yield per acre per year to be expected under reasonable manage- ment and protection.....	300 Bd. Ft.
Minimum annual yield to be expected on 1,500,000 acres.....	450,000,000 Bd. Ft.
Possible maximum yield per acre per year.....	1,000 Bd. Ft.
Possible maximum annual yield on 1,500,000 acres.....	1,500,000,000 Bd. Ft.

Annual Freight Bill

on lumber from other states.....	\$3,000,000
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*As reported by the U. S. Forest Service.

†As reported in the 1920 Census.

The Need for Forestry in Connecticut.

New England was one of the first forest regions in the United States to be exploited for lumber and at present is probably suffering more acutely from timber scarcity with resulting high prices than any other region. This condition has come about in a very natural manner. As timber becomes scarce in any section the bulk of the lumbermen move to some new region. When the supply in New England ran low the movement was to western New York, Pennsylvania and the Lake States. Later it was to the forests of the Southeastern States and more recently to the Pacific Coast.



Long Hauls Make Lumber Costly.

Each successive move has taken the major part of the industry farther from New England. *The result is that this region has been obliged not only to pay an increasingly higher freight rate due to a longer haul but also to compete for the products needed with regions which lie between it and the source of supply.*

The Pacific Coast timber which is the only large remaining virgin stand in the country will, at the present rate of cut, last about 50 years. *When it is gone this country will be dependent chiefly on the current growth from lands that have been cut over.* Logging methods in virgin stands have been very wasteful with practically no effort to provide in any way for a new crop to replace the one removed. In addition much of the area already logged has been burned over one or more times. The result is that there are in the United States some 80,000,000 acres of barren waste which is producing nothing and a much larger area on which the productivity is not over 20% of what the land is capable of growing.

CLASSIFICATION OF FARM LAND BY COUNTIES.*

	Connecti- cut	Counties							
		Fairfield	Hartford	Litchfield	Middlesex	New Haven	New London	Tolland	Windham
Total land area, acres.....	3,085,000	404,000	466,000	592,000	236,000	386,000	422,000	259,000	320,000
Area in farms, acres.....	1,898,000	225,000	295,000	377,000	122,000	188,000	288,000	183,000	220,000
Per cent. of total area in farms.	62	56	63	64	52	49	68	71	69
Area improved land in farms, acres.....	701,000	108,000	143,000	136,000	35,000	76,000	80,000	53,000	70,000
Area unimproved land in farms, acres.....	1,197,000	117,000	152,000	241,000	87,000	112,000	208,000	130,000	150,000
Area average farm, acres.....	84	58	62	124	87	70	105	93	99
Area improved land on aver- age farm, acres.....	31	28	30	45	25	28	29	27	32
Area unimproved land on aver- age farm, acres.....	53	30	32	79	62	42	76	66	07
Per cent. of unimproved land on average farm.....	63	52	52	64	71	60	72	71	68
Number of farms.....	22,600	3,900	4,700	3,000	1,400	2,700	2,700	2,000	2,200

*From the 1920 census.

If the United States must ultimately depend for timber on current growth rather than on the accumulated growth of centuries (virgin timber) the aim should be to divide up the country into several units, each practically self supporting with regard to timber. The result of such a division would be to lower transportation costs and stabilize prices. New England should form such a unit. There is enough non-agricultural land within its borders to produce timber in sufficient amounts and of suitable kinds for its industries. Northern New England is a forest region.



Conifers Increase the Yield on Hardwood Land.

It can produce much more timber than is needed locally and will probably always have a surplus to export to other districts. Its products are chiefly soft wood. Southern New England is an industrial region and consequently a big market for forest products. *It has enough non-agricultural land to produce a quantity of lumber sufficient for its needs but it cannot grow all the kinds required.* It must therefore import lumber but to offset this it should have an equal quantity to export in order to preserve the balance.

Connecticut is a part of southern New England and the remainder of this report will be devoted to its forest problems, with suggestions for the improvement of the forests, particularly the farmers' woodlots.

THE FORESTS OF CONNECTICUT.

The annual consumption of sawed lumber in Connecticut is approximately 350 million board feet and of this amount only 65 million board feet or *about one-fifth is produced within the state.*

The total land area of the state is 3,085,000 acres and of this at least one half, or 1,500,000 acres, may be classed as non-agricultural or forest land. On the assumption that the forest land area is 1,500,000 acres, *the present annual production per acre is only 40 board feet.* This is very low. *With reasonable care and protection 300 board feet per acre per year is the minimum that ought to be expected and the possible maximum might run as high as 1,000 board feet per acre annually.* On the basis of 1,500,000 acres, the total annual yield should be between 450 million and 1,500 million board feet.

These figures indicate a two-fold problem.—

1. **A land problem.** By better treatment and protection to make the poorer non-agricultural lands produce a reasonable crop, thereby raising their status from that of a doubtful asset or even a liability to that of a profit producing asset.

2. **A timber problem.** To produce annually within the state at least 450 million board feet of sawed products. This would make the state practically self supporting. Some timber would, of course, be imported to supply the need for kinds that cannot be grown here but to offset this there would be some native timber for export.

It may be noted from the table (page 134) that there are 1,187,000 acres, or 38% of the land area of the state, not in farms. It is not possible to determine definitely the present status of the land not in farms but it may be reasonably assumed that not less than 25% of it, or 300,000 acres, is forest land. This added to the 1,200,000 acres on farms makes 1,500,000 acres which is a conservative figure and agrees closely with the figure of 1,483,000 acres obtained by the forest survey of Connecticut in 1914.* It is quite possible that this estimate could be increased by including with the forest land, all pastures reverting to forest. This may or may not be correct. Furthermore it involves the question of proper utilization of land which beyond the scope of this report.

This table shows that 63% of the farm land of the state is unimproved. This figure varies with the several counties but in no case is it under 50%. Improved land is given in the census as "land regularly tilled or mowed, land in pasture which has been cleared or tilled, land lying fallow, land in gardens, orchards, vineyards, and nurseries and land occupied by buildings." Unimproved land constitutes the remainder of the farm and is chiefly woodland, brush land, waste land and swamp. This unimproved land is usually too poor to till and of a doubtful value for pasture.

*A Forest Survey of Connecticut by Albert E. Moss.

In general it is fit only to grow trees because they are not exacting in their soil requirements.

Obviously the forest problem is largely a farmers' problem since farmers as a class own the most woodland. For most of them the situation is an acute one because their woodlots, averaging in area more than one-half the farm, are in a very low state of productivity due to fire, ravages of various diseases and insects, indiscriminate cutting and general misuse. In fact, it is a question whether or not many woodlots are paying expenses (i.e., interest and taxes) to say nothing of showing a profit. *An industrial*



Thinning in a Young Hardwood Stand.

organization either improves a poor paying line or abandons it. The farmer must do likewise for he cannot continue indefinitely to make his tilled land support itself and the woodlot also. If the woodlot cannot be made to pay it should be abandoned, but in most cases this will not be necessary because with reasonable handling it will improve to a point where it will pay.

In improving the forest there should be three main objectives:—

1. To handle the present deciduous or hardwood forest for better quantity and quality production. Quantity may be increased by favoring fast growing species and by reducing the competition which is always so keen in natural stands. Quality may be improved by favoring the most valuable species and the best individuals. Both objects can be attained through systematic thinning.

2. To gradually introduce conifers into the hardwood stands. Most conifers grow faster and yield more per acre than hardwoods. Moreover 80% of all lumber used is softwood from coniferous trees.

3. To treat the forest as a source of repeated crops of timber capable of improvement, rather than a non-renewable resource to be exploited to its fullest extent and then abandoned. Field crops require weeding, thinning, protection from enemies and suitable treatment to assure reproduction. Forest crops require similar care, though not as intensively applied, to secure comparable results.

Some Suggestions to the Woodlot Owner.

1. Thin the young woodlot systematically thereby getting rid of the poorer species and unhealthy individuals, allowing the best specimens to develop without excessive competition. The final yield will be as large and of better quality than in an unthinned stand and the material taken out will more than pay for the operation.

2. Plant at least 1,000 conifers each year for timber production. The cost will be not over \$15.00 and the area covered from one to two acres depending on whether the planting is in the open or in brush. The attention required by a plantation is relatively small.

3. Grow Christmas trees on old pastures on a ten year rotation. This is a better use of land than allowing it to grow up to grey birches and is far more profitable. Up to three thousand trees per acre can be used for this purpose.

4. Avoid selling timber by the lot. In most cases the buyer reaps an excessive profit, a part of which rightfully belongs to the owner.

5. Make use of the present forest tax law. The law is not ideal but it favors the forest owner far more than the town assessors. Work for a better tax law.

6. Keep domestic animals out of woodland as a general rule. A limited amount of grazing may do no harm but over-grazing is detrimental to the woodlot. The better plan is to fence off the amount needed for grazing and use it only.

7. Grow saw timber. Cordwood should be obtained from thinnings and not by skinning immature stands. This latter process puts the lowest value on all species whereas such species as hickory, ash, whitewood, and red oak will bring high prices if grown to saw-log size.

8. Market more of the minor products of the forest, as ferns, mountain laurel and maple sugar.

9. Look upon the woodlot as one of the resources of the farm and not as something to pay taxes on. Figure out just how profit-

able the woodlot is. If it is not paying taxes and other overhead charges and allowing the owner a fair return for his investment in land, try to find out where the trouble is and remedy it.

10. Cooperate with the Connecticut Forestry Association, an organization which is working to advance forestry in the state.

11. Consult the Foresters of the Connecticut Agricultural Experiment Stations, New Haven, and the Connecticut Agricultural College, Storrs.



Thinned Pine Plantation, 28 years old.

Benefits to be expected from the improvement of the forest.

1. To the owner.
 - a. Winter employment for farm labor and teams.
 - b. Full utilization of land, no unprofitable acres.
 - c. Income more evenly distributed throughout the year.
 - d. Greater farm value if the owner wishes to sell.
 - e. Larger loans from the Federal Land Bank.
2. To the community.
 - a. Plentiful domestic lumber with low freight rates.
 - b. More woodworking plants resulting from an assured supply of materials. This means closer utilization and better prices for woodlot products.
 - c. Better protection of water supplies.
 - d. Increased value of the forests for recreation.

CONCLUSION.

There have been *three major causes* for the present low productivity of the forests of Connecticut and of the United States as a whole. These must be corrected before any real progress can take place. They are:—

1. **Forest Fires.** It is a reasonably safe statement that fire has been the greatest single factor in lowering the yield of our forests. At least two-thirds of all forest fires are caused by negligence or carelessness. This condition can best be handled by building up a strong public sentiment against the persons responsible.

2. **Inequitable taxation.** A woodland owner must carry his forest for several decades before he gets any returns. During the growing period the town assessors may and usually do raise his valuation several times. *This often forces the owner to cut sooner than he otherwise would.* This method of taxing woodland may be likened to taxing a corn crop four or five times during a season and at a higher valuation each time.

3. **Poor cultural practice,** both *in caring for the current crop and in failing to provide for future crops* as well as unnecessary waste in logging and milling.

The forest owner cannot be blamed directly for the evils resulting from fire and taxes except that he has endured the losses therefrom without attempting to relieve the situation. Better legislation and stricter enforcement of existing statutes are needed. Forest owners can get these things only by going after them and pulling together.

The evils arising from not using practical forestry methods in growing and harvesting the timber crop can be charged directly to the owner and can be corrected only by him. It is true that the financial inducements to use better methods have not been great but the same may be said of many other things that we undertake with the conviction that they are worth while. If our grandfathers had adopted reasonable methods in handling their woodlots we would not now be obliged to pay a dollar for the material for a pantry shelf. If we are content to continue to use their methods it will probably cost the next generation two dollars. Is this fair?

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DECEMBER, 1924

GIFT
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Connecticut Agricultural Experiment Station

New Haven, Connecticut



The Rainbow Forest Plantations

Guide to Experimental Plots

and

Report of Progress

1924

Forestry Publication No. 15

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CONNECTICUT AGRICULTURAL EXPERIMENT STATION

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December, 1924.

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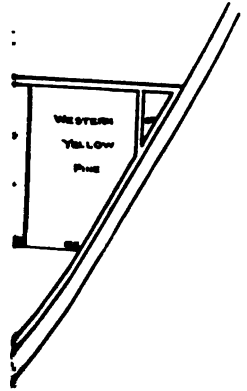
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Tobacco Sub-station at Windsor

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Handwritten text in a cursive script, likely a letter or document. The text is written in a dark ink on a light-colored paper. The handwriting is fluid and somewhat slanted, characteristic of 18th or 19th-century cursive. The text is arranged in several paragraphs, with some lines indented. The overall appearance is that of a historical document.



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NT STATION

The Rainbow Forest Plantations

Guide to Experimental Plots

and

Report of Progress

1924

By

HENRY W. HICOCK

INTRODUCTION

HISTORY AND DESCRIPTION OF TRACT.

The Rainbow Forest Plantations of the Connecticut Agricultural Experiment Station occupy approximately 100 acres in the towns of Windsor and East Granby, about one-half mile west of the village of Rainbow. The land was purchased at a low figure because its value for field crops had been demonstrated to be very low. As a matter of fact, cultivation had been given up several years prior to its acquisition by the Station and it was in various stages of reversion to forest growth. During recent years adjoining property, on which the soil differs but very little from that on the greater part of the Station land, has been cleared and utilized for the production of shade grown tobacco. The land now occupied by the plantations would probably yield a greater return per acre if utilized for shade tobacco instead of for the production of forest crops.

The tract lies on a practically level bench about 100 feet in elevation above the Farmington River and 160 to 180 feet above sea level. The soil* on the major portion of the area is what was originally mapped by the U. S. Bureau of Soils in 1899 as "Windsor Sand", which name was changed in their Bulletin 96 to "Merrimac Coarse Sand." It is part of a deep deposit of glacial outwash material which forms an extensive plain in this portion of the state. The soil is a coarse sand, containing less than 10% of silt and clay, and the texture is very nearly the same to the depth of many feet. The surface soil contains sufficient organic matter to give it a medium brown color to a depth of 5 to 7 inches. The subsoil is of a yellowish color to a depth of about 3 feet, where it grades gradually to the dull gray which is imparted to it by the

*Notes on soil conditions furnished by Mr. M. F. Morgan of the Dept. of Soils, Connecticut Agricultural Experiment Station.

undiscolored coarse granules of impure quartz sand which predominate.

In small local areas (referred to in the plot descriptions as "barren areas") near the western border of the tract, especially in Plots 16, 44 and 45, the soil is somewhat coarser than is the rule, and contains so little silt and clay that it has even less coherence than usual. On such areas all plant growth is either much stunted or is altogether lacking. The change from these areas to those that support a normal plant growth is very abrupt. Trees planted on the sterile spots either grow very slowly or do not survive at all. Red pine seems to make a little better growth on them than does white, but the needles of both are yellow and in general the trees are crooked and sickly.

On the higher ground in the northeastern portion of the tract, especially in Plots 68 and 69 and in the northern portions of Plots 59 and 60, the soil is finer in texture consisting of about 7 inches of medium brown loamy sand surface soil, with a yellow subsoil of a similar texture to a depth of about $2\frac{1}{2}$ feet overlying the unweathered glacial till. The latter is made up largely of a mass of red shale and sandstone rock fragments of moderate size (less than 6 inches in diameter), with a considerable admixture of grayish sand and fine gravel. This soil type was identified in the 1899 Bureau of Soils Survey as "Enfield Sandy Loam" but this name was changed to "Manchester Fine Sand" in U. S. Bureau of Soils Bulletin 96.

The natural forest growth of the region is inferior hardwoods (mostly grey birch and oaks) and pitch pine, with some chestnut and white pine. The latter species is the only one to make good growth although the chestnut did well before it was attacked by the blight. Land abandoned for agriculture first seeds in to broom sedge and similar plants, followed by grey birch and pitch pine. Later stages of reversion show a diminution of grey birch and an increase of inferior oaks and pitch pine, with some white pine coming in.

The plantations were begun in 1901 on the present tract and in 1902 on another known as Mundy Hollow. The latter was abandoned after a few years. The plans were made for the first Forester of the Station, Mr. Walter Mulford, by the U. S. Forest Service, and comprised an elaborate series of experiments in artificial regeneration of hardwoods and conifers by seeding and planting. The tract was divided up into plots varying in size from $\frac{1}{4}$ acre to 6 acres in area, a large percentage of them averaging about 1 acre. Wherever feasible, the plots were laid off as rectangles. Numerous methods were tried out. These are described later under individual plots, insofar as the results of these methods are now present. Many of the earlier experiments were complete failures and in such cases no specific reference is made to them in this publication but the reader is referred to Reports of the Station for the years 1906, 1907 and 1912.

Some method of artificial regeneration has been undertaken nearly every year since the plantations were started, the amount varying with the funds available, until at present practically the entire tract is under some kind of forest cover.

For a number of years a nursery was operated in connection with the tract but this practice was abandoned and stock procured either from the Station nursery at Mt. Carmel or by purchase from commercial nurseries.

The plantations have always been used as a field laboratory for the study of insects and fungi by the Entomological and Botanical Departments of the Station, and since 1919 as an object of field study by students from the Yale School of Forestry, who have laid off sample plots and made thinnings in some of the older stands. This work is recorded under individual plots.

The tract has been under the general oversight of a local resident since its inception. Mr. Judson Leonard had charge from 1901 to 1909; Mr. Henry Palmer, from 1909 to 1920. Mr. Frederick M. Snow, the present superintendent, lives near the end of the Rainbow trolley line and about $\frac{1}{2}$ mile from the plantations. He will be glad to aid visitors in every way possible. Forestry operations have so far consisted of planting, cleaning, a small amount of thinning and control of the white pine weevil. Such work has been done either by the local superintendent, by members of the staff of the Forestry Department or by students from the Yale School of Forestry.

As yet the tract has not produced sufficient revenue to pay expenses, although carrying charges have been considerably lessened by the sale of cordwood from cleanings, of some chestnut and large pitch pine for saw-logs, of overtopped spruce for Christmas trees and of Mugho pine for ornamental purposes. In time the tract as a whole should become nearly self-supporting although it will probably never be wholly so.

Only a small amount of planting is needed to bring the entire tract under a forest cover. Future operations will consist of thinning the older stands as they need it, of weevil control, of cleanings and other improvement cuttings, of pruning experiments, of experiments in the most effective methods of cutting hardwoods to obviate rapid sprouting, etc.

The amount of damage from various causes has been relatively small. A rather elaborate system of exterior and interior fire lines, which are harrowed frequently, has been instrumental in keeping the burned area under 6 acres during the last 22 years. Rodents kept the red oak cut back so that experiments with this species are almost a complete failure. Several species of insects have proved troublesome but in only one case has an insect destroyed the entire value of an experiment. The locust borer, *Cyllene robiniae*, mined the trunks and limbs of the black locust so severely that the experiments with this species have been

abandoned. The insect requiring the most work to control is the white pine weevil, *Pissodes strobi*, which attacks the terminal shoot of white pine, Japanese red pine, Mugho pine and Norway spruce, thus deforming the stem. White pine is most severely attacked, followed by the others in the order named. Cutting and burning the infested leaders is the most practical method of control. This work is needed annually. Norway spruce seems to recover better from the injury than do the pines. The spruce gall, *Chermes abietes*, has made much of the Norway spruce unsightly and has probably impaired the growth to some extent although no stunting is apparent and no trees have been killed. The chestnut blight, *Endothia parasitica*, persistently kills back the chestnut trees used in the early experiments. Two rusts have also been found on different species of pines. One, *Peridermium cerebrum*, found on jack pine, has for its alternate host, various species of oaks. This rust was evidently brought in from Michigan on the planting stock and no new outbreaks have been found. The other rust, *Peridermium pyriforme*, which has for alternate hosts two species of toadflax, *Comandra pallida* and *C. umbellata*, has been found on Austrian, Scotch and bull pine. On the first two species it does not seem to have done much damage beyond deforming a few trees. The bull pine, however, seems more susceptible. A few trees die from the disease each year and indications are that the species will eventually be killed out here.

DESCRIPTION OF PLOTS.

Following is a description of the seventy plots which make up the tract. A preliminary survey was made by Mr. S. E. Parker in March, 1923 and all measurements and counts are as of that date unless otherwise noted. Heights were taken with a 10 foot pole or with a Faustmann hypsometer, and diameters with a diameter tape.

Plot 1. Exotic conifers. Area about .7 acre. Planted in the spring of 1907 by sections as follows: east side, Austrian pine, 2 year seedlings, spaced 5 x 5 feet; center, European larch, 2 year seedlings, 5 x 6 feet; west side, Scotch pine, 2 year seedlings, 6 x 6 feet. In 1911 a fire destroyed about $\frac{2}{3}$ of the plot and in 1913 the blanks were filled with Douglas fir, 7 year transplants and Chinese arbor-vitae, 6 year transplants. Two partial rows of Japanese red pine planted about 1913 occur on the west side of the plot. A description of this species under Plot 5 will cover this part of Plot 1. The arbor-vitae was a complete failure and the fir, coming from Pacific Coast seed, was not hardy and is represented by a few stunted trees. The failure of these two species has left the stand quite open and irregular although some native pitch pine helps to increase the density. Scotch pine has made the best growth, averaging 23 feet tall and 3 inches in diameter. The

trees are fairly uniform in size but are somewhat crooked. Austrian pine has done fairly well, averaging 9 feet tall and 1.4 inches in diameter. The larch averages 1 foot taller than the Austrian pine but individuals vary greatly, some equaling the Scotch pine in height while others are mere shrubs. The plot was cleaned by lopping hardwood brush in 1919. Several individuals of Scotch and Austrian pine infected with *Peridermium pyrifforme* (See page 106) were removed in 1910.

Plot 2. White pine. Area .8 acre. Planted in the spring of 1907 with 2 year seedlings, spaced 6 x 6, 5 x 5, 4 x 4, and 3 x 3 feet. In 1911 a fire destroyed the north end of the plot including the 4 x 4 and 3 x 3 foot spacings and in the spring of 1913 blanks were filled with 8 year white pine transplants spaced 5 x 5 feet, thereby destroying the value of the original experiment in different spacings. On the unburned south end only about ten per cent of the trees are missing and the stand is just closing. Only a few trees have any dead limbs. The average size on the 6 x 6 foot spacing is height 13 feet, diameter 2.0 inches and on the 5 x 5 foot, height 9 feet; diameter 1.9 inches. The 1913 planting averages 5.5 feet high but is very open and irregular owing to the failure of about 50% of the trees. Weevil damage (See page 106) amounts to 25% for the plot as a whole. A more recent fire (1923) destroyed about $\frac{1}{3}$ of the 1913 planting. The plot was cleaned by lopping birch in 1919.

Plot 3. Pitch pine. Area 1.3 acres. In 1902 seed sown on cultivated strips $1\frac{1}{2}$ feet wide and 4 feet apart as follows: on the south half at the rate of 2 pounds per acre and on the north half at the rate of 1 pound per acre. The seed was brushed in. On the south half a very dense stand resulted. Trees average 1 foot apart in the rows, 17 feet in height and 2 inches in diameter, and have dead limbs for 8 feet above ground. About 60% of the trees have died from crowding. The stand on the north half is not so dense. Trees average 6 feet apart in the rows, 15 feet in height and 3 inches in diameter, and have dead limbs for 3 feet above ground. Very few trees have died from crowding. Spacing in the rows is not uniform and the stand on both sections is very uneven, especially on the north half but here gaps are being filled by natural seeding. Several trees badly infected with *Peridermium pyrifforme* were removed in 1910. On both sections the trees have the poor form characteristic of pitch pine in this region. Compare with Plot 49.

Plot 4. White pine—Red oak—Scotch pine. Area .7 acre. Planted in the spring of 1904 with red oak, 3 acorns in a hole, and white pine 2 year seedlings, spacing 6 x 6 feet, a solid row of oak alternating with a row of oak and pine mixed. Losses were small for the first three years. Since then rodents have kept the oak cut back so that at present only 40 % of them are living and of

these only 15% have made even fair growth. However, an occasional individual has done nearly as well as the pine showing that the species will grow on poor soil if not attacked by rodents. About 1913, gaps caused by failure in the oak on the south end of the plot were filled with Scotch pine; the north end remains unfilled, leaving the white pine spaced 12 x 12 feet. With this wide spacing the white pine is thick boled, badly deformed by weevil and shows dead branches for only 3-4 feet. Where Scotch pine has been used it has closed the stand and is approximating the white pine in height. It has dead branches for 3-4 feet above ground but it has not yet influenced the pruning of the white pine growing with it. Average sizes: heights,—white pine, 19 feet; red oak, 7 feet and Scotch pine, 16 feet: diameters,—white pine, 4.5 inches; red oak, 1.0 inch and Scotch pine, 3.0 inches. The north end of this plot may be compared with Plots 48 and 51 where red oak and white pine were planted together but with different arrangement of species and the south end with Plots 35, 36 and 37 where Scotch pine has been used as a filler in older white pine plantations..

Plot 5. Japanese red pine and White pine. Area 1.4 acres. Planted in the spring of 1910 with Japanese red pine 2 year seedlings, spaced 6 x 6 feet. The following summer was very dry and a 50% loss resulted. Blanks were filled in the spring of 1911 with 3 year transplants of the same species. Further failures resulted and in 1913 blanks were filled with white pine 4 year transplants. The present stand is practically complete and is made up of $\frac{2}{3}$ Japanese red and $\frac{1}{3}$ white pine. The plot is just about to close. It has been kept free of hardwood competition and is therefore open grown. The Japanese red pine shows a 10% damage by weevil as compared with 45% for the white pine. The latter averages 8 feet in height and the former 7 feet. The Japanese red pine does not appear to be a good tree to plant in the open because of its tendency to divide at the base into many stems. In the spring of 1924 all leaders, except one, were removed from each Japanese red pine in an attempt to make this species produce one good stem. The results of this work are not yet apparent but the plot may be compared with Plot 52 where this tree has been grown under similar conditions without reducing the number of leaders. The plot may also be compared with Plot 19 where the species was grown for about 10 years under a dense shade of birch. Japanese red pine has borne cones very prolifically for a number of years and many seedlings up to 10 inches tall are growing in the openings.

Plot 6. Western yellow (bull) pine and White pine. Area 2.7 acres. Planted in the spring of 1908 with bull pine 2 year seedlings, spaced 5 x 5 feet. Losses up to 1912 had amounted to 45% and in 1912 and 1913 blanks were filled with 4 year white pine transplants. Further losses have occurred and these have

not been filled, so that the present stand is 35% bull pine, 35% white pine and 30% blanks. The white pine, even though it has been very heavily damaged by weevil (65%), now equals the bull pine in height which now averages 6.5 feet. The bull pine is subject to attack by *Peridermium pyriforme*, a fungous disease which kills a few trees each year. In fact, it seems probable that this disease may eventually kill out the species here. Compare with Plot 66.

Plot 7. White pine. Area 2.3 acres. Planted in the fall of 1913 with 3 year transplants, spaced 6 x 6 feet, as a test of fall planting. The experiment was a complete success, over 95% of the trees being alive at present. The stand is irregular, the trees varying in height from 2 to 10 feet and averaging 6 feet. This unevenness is due to some extent to weevils which have attacked 60% of the trees but numerous individuals are stunted without having been attacked by weevil. The stand apparently underwent a period of stagnation for about eight years and the irregularity may be due to the fact that some trees are recovering sooner than others. This stagnation period is characteristic of all white pine plantations on the tract. The species seems to grow slowly for a longer period after planting than most of the others used. The plot has had numerous weevil cuttings and was entirely cleared of birch in the winter of 1921-1922.

Plot 8a. Red pine and Norway spruce. Area 1.7 acres. Cleared in the winter of 1921-1922 of birch for cordwood and planted in the spring of 1922 with red pine and Norway spruce 3 year transplants, spaced 6 x 6 feet, and alternating by rows except the four rows on the west side which are all pine. Most of the birch was at the south end of the plot. The plantation is over 90% complete but the pine averages 18 inches tall and looks thrifty, whereas the spruce is only 6 inches in height and is yellow and sickly except where it received shade from small birch sprouts. It would seem that this mixture is not feasible in the open as the pine will probably suppress the spruce in the same way that the white pine did on Plot 69, leaving the red pine spaced 6 x 12 feet with the spruce forming an understory. The mixture might have been more successful under a heavy brush cover which would have held back the pine more than the spruce and acted as a nurse for the latter until it was well started. (See plot 42.)

Plot 8b. Norway spruce. Area 1.3 acres. Cleared with Plot 8a leaving a few scattering native white pines about 15 feet high. Planted in the spring of 1924 with 2 year seedlings, spaced 5 x 5 feet, as a Christmas tree experiment. The stock was small, the season dry, and only about 10% of the trees survived the first summer. Plot may be compared with Plot 18 where white spruce stock of the same size was planted under an overwood. The latter

plantation is over 90% complete thus demonstrating the value of cover during the early years.

Plot 8b contains much chestnut from an experiment started in 1903. It is interesting to note that this species, even though killed back repeatedly by blight, still persists on this poor leachy soil better than most of the hardwoods used, red oak and locust excepted.

Plot 9. Pitch pine and Hardwoods. Area about .6 acre. Natural growth, not planted.

Plot 10. Norway spruce. Area about .6 acre. Planted in 1912 under a stand of old growth chestnut. Spacing is irregular but averages about 8 x 8 feet. The chestnut died and was removed in 1922 leaving a younger growth, consisting principally of oak, as a cover for the spruce. This cover was opened up in the spring of 1923 to give the spruce more light and will be further reduced or removed at a later date. The spruce has grown slowly but the trees are healthy, except for a small amount of weevil damage, and show every indication of coming through and forming a stand. Spruce is very tolerant and while it will not make fast growth under dense shade it will persist for a long time and, when released, makes a good recovery and increases in size rapidly. Compare with Plot 42, an older spruce plantation under shade which has been reduced from time to time.

Plot 11. Native white pine. Birch cutting experiment. Area .7 acre. The north end of the plot has been devoted for some years to an experiment in bringing a scattered stand of natural reproduction of white pine through a heavy cover of old field grey birch. The pine is doing fairly well but has been badly weeviled and is of poor form.

In October, 1924, an experiment was started to determine the sprouting qualities of birch under different methods of cutting at different times of year. This experiment should give some valuable information on the best season to release plantations and the best cutting methods to use in order to get a minimum of sprouts. The experiment was laid out as a number of different series of four sections each, each series to be cut at a different time of year. One series was cut during October, 1924. Another will be cut in the spring of 1925, and still another in mid-summer, 1925. The four sections in each series are as follows:

- a. Check—no cutting.
- b. Birch cut off close to the ground.
- c. Birch lopped off 2 to 3 feet above ground.
- d. Birch lopped partly off and bent over so that the trees will still continue to live.

Plot 12. White pine. Area .6 acre. Planted in the spring of 1902 with 3 year seedlings, spaced 5 x 5 feet, under a cover of grey

birch 15 to 20 feet tall. Fail places were filled in the spring of 1904 with 3 year transplants. The cover was removed in 1910 and 1911 and a final release cutting was made in 1919. This is one of the best plantations of white pine on the tract. Because of the heavy cover for the first 10 years the average growth has not been rapid (average height 19 feet and diameter 3 inches) but the trees are of excellent form, uniform in size and with almost no injury from weevil. Dead limbs extend to 7 feet above the ground and are quite small. Annual height growth almost doubled after the cover was removed in 1910-11.

Plot 13. Norway spruce and Balsam fir. Area about 1.2 acres. In 1910, 71 balsam firs were planted along the northern border of Plots 11 and 12, and about 1916 the remainder of the plot with the exception of a narrow strip to the west of Plot 12 was planted with Norway spruce. Spacing is irregular but averages about 8 x 8 feet. Planting was done under a moderately heavy cover consisting of old pitch pine and a lower stand of hardwoods. Both spruce and fir average 5 feet tall and show the effect of too much shade. However, they are of good color and look healthy, and on removal of the overwood, should make an increased growth in height. The cover was thinned in the fall of 1923 to give the planted trees more light but a further thinning is needed as the cover is still too dense.

Plot 14. Scotch pine. Area 1.2 acres. Planted in the spring of 1907 with 2 year seedlings, spaced 5 x 6 feet, the trees set in furrows plowed through the brush to try out Scotch pine in competition with an advanced hardwood growth. A part of the brush was removed in 1910 and the balance in 1913. A second release cutting was made in 1919 and third in 1924. This should be the last one needed. In addition, several large chestnuts were removed from the south side in 1921. The experiment was only a partial success because, in spite of frequent releasings, the hardwoods killed out over $\frac{1}{3}$ of the pine. However, those that have survived have made good growth and are in sufficient numbers to form the final stand. Average height 22 feet; diameter 4.5 inches. Dead branches extend for 10 feet above the ground. This plot demonstrates very well the inadvisability of attempting to grow Scotch pine under any kind of cover. The species is very intolerant and cannot stand even moderate shade. Compare with Plot 23 which was kept entirely free of brush.

Plot 15. White pine. Area .9 acre. Planted in the spring of 1906 with 3 year seedlings, spaced 5 x 6 feet. This plot was started and has been treated in about the same manner as Plot 14, but the trees show far less injury from hardwood competition than do the Scotch pines. About 90% of the trees are still living and the result is a very dense stand with trees averaging 19 feet in height and 3.5 inches in diameter. Dead branches extend for

6 feet above ground. All brush was cleaned from the plot in 1913 and a second and final release cutting was made in 1919. Weevil damage has been very slight, probably because of the density of the stand and the fact that the trees were in brush for seven years. The stand offers a good example of the results of close spacing, i. e., good form with small side branches that are killed early. It is probably too dense for practical purposes as the first thinning will not yield enough to pay for making it. All vegetation has been shaded out and 2 to 3 inches of needles cover the ground.

Plot 16. White pine—Red pine—Japanese red pine. Area 3.7 acres. Spacing 5 x 5 feet. Planted in 1917 as follows: west side, pure red pine; center, white pine and Japanese red pine alternating by rows; and east side, red pine and white pine alternating by rows. The red pine has made the best growth, averaging 5 feet in height, followed by the white with 4 feet and the Japanese red with 3 feet. The stand is practically complete, blanks amounting to less than 15%. The white and the Japanese red pines have both been attacked by the weevil, the former more heavily than the latter. The Japanese red has developed the same bushy habit as in Plots 5 and 52, and is bearing cones prolifically but no seedlings were found. The stand has not yet closed although the pure red pine on the west side has nearly done so. Except immediately under the trees, the crowns have not killed out the vegetative cover. Numerous barren areas occur on this plot. (See page 104.)

Plot 17. Headquarters Site. Area .9 acre. The east end of this plot is used as a location for a portable headquarters cabin. The remainder of the plot which was formerly the old nursery site contains an assortment of many kinds of trees left in the old nursery rows, together with enough later plantings of red and white pine to make up a stand.

In October, 1924, an experiment in pruning young conifers was started directly behind the cabin in a planting of red pine made in the fall of 1919. The experiment includes some 50 trees divided about equally among 4 rows. The row nearest the cabin was pruned to leave a leader and two whorls of branches, the next to leave a leader and one whorl, the third to leave a leader and 3 whorls and the fourth left unpruned as a check. For row 1 (east), the live crown averages about $\frac{1}{2}$ the total height of the tree; for row 2, $\frac{1}{3}$ the height; for row 3, $\frac{1}{4}$ the height; and for row 4, the entire height. A whorl of branches is to be removed from each row (the check excepted) each year, the object being to find out how much the crowns can be reduced without diminishing the growing power of the trees.

Plot 18. White spruce. Area .7 acre. Planted in the spring of 1924 with 2 year seedlings, spaced 8 x 8 feet, under a cover made up of pitch pine 8 to 10 inches in diameter with an understory of

smaller hardwoods. Less than 10% of the trees had died at the end of the first growing season, demonstrating the fact that spruce (2 year stock) can be planted successfully on a leachy soil if given sufficient protection against drying out. This plot may be compared with 8b where small stock of Norway spruce was planted in the open, the result being almost a complete failure. The cover should be removed, or at least greatly reduced, within five years.

Plot 19. Japanese red pine. Area 1.2 acres. Planted in the spring of 1910 with 2 year seedlings, spaced 6 x 6 feet. Loss was heavy and blanks were filled in 1911 with 3 year transplants of the same species. There were further failures and at present the stand is only 50% stocked. In 1919 the hardwoods, which had completely outgrown the pine, were thinned but not heavily enough and in 1922 they were removed altogether. The interesting feature on this plot is that hardwood competition forced the pine to confine its growth normally to one stem. As a matter of fact this competition was so severe that it caused the pine to become very slender and crooked. Since releasing, however, the trees have recovered and made a much increased height growth. Weevil damage has amounted to very little and the production of cones has been small. This plot forms a very marked contrast to Plot 5 where this species was planted in the open. The average height on Plot 19 is 12 feet, nearly twice that on Plot 5. It would seem that the proper conditions under which to grow this tree successfully would be under a cover kept sufficiently dense to prevent the pine from producing several stems, but not dense enough to cause suppression and crooked, slender boles. The species seems to be fairly tolerant of shade, probably ranking with red pine in this respect.

Plots 20 and 21. White pine and Scotch pine. Area 1.3 acres each. Planted in the spring of 1910, using 4 year transplants of white pine and 2 year seedlings of Scotch pine. Spacing 5 x 5 feet, the species alternating by rows. Scattered white pine set out in 1904 were ignored in the 1910 planting. The experiment does not promise to be a success. The Scotch pine is growing faster than the white and probably will suppress it. In fact the Scotch pine compares favorably with the white planted in 1904. Failures have amounted to over 30%, chiefly in the white pine and the stand is ragged and has not closed. The Scotch pine has dead limbs for a height of 4 feet, while the white has no dead limbs. The Scotch pine averages 17 feet in height and 3 inches in diameter; the white averages 10 feet tall and 2½ inches in diameter (1904 planting excluded). Weevil damage in the white pine has been very slight, due probably to the fact that this species has always been shorter than the Scotch and therefore protected by it. These plots demonstrate that it is not feasible to plant white and Scotch

pine at the same time in mixture. Comparison may be made with Plots 4, 35, 36, 37 and 56 where Scotch pine was used as a filler in white pine plantations that were much older, and with Plot 34 where white pine was used as a filler in a Scotch pine stand that was several years older.

Plot 22. Red pine and White pine. Area .8 acre. Planted in the spring of 1902 with red pine 4 year transplants, spaced $4\frac{1}{2} \times 5$ feet (except for about 100 trees at the north end which are white pine apparently planted at the same time and with the same spacing). Failures in the red pine were filled in 1904 with the same species. The stand has but few blanks. The red pine averages 20 feet tall and 3.8 inches in diameter and the white, 16 feet tall and 2.4 inches in diameter. Red pine has dead branches for 7 feet above ground while the white has them for only 4 feet. The dead branches on the red pine are small, brittle and may be broken off easily though most of them still persist. The white pine has been damaged but very little by weevil, probably because this block of trees is almost completely surrounded by taller trees. This plot may be compared with Plots 23, 28 and 49, all of which were planted at the same time and under about the same conditions, but with different species. The spacing on Plot 22, as well as on Plots 23, 24 and 28, is too close from a practical standpoint. The first thinning will not yield enough returns to pay for making it. Theoretically, the narrow spacing is ideal insofar as it causes the trees to produce small side limbs which die early.

Plot 23. Scotch pine. Area .6 acre. Planted in the spring of 1902 with 3 year seedlings, spaced 4×5 feet. The plot has been kept free from hardwood competition and there have been practically no failures. Scotch pine has shown the best growth of any tree used on the tract, with the possible exception of black locust. Heights now average 29 feet and diameters 3.5 inches, while some individuals have reached a height of 33 feet and a diameter of 5 inches. Dead branches extend for 14 feet above the ground and are quite rotten, more so than those of red and white pine of the same age and spacing. The trees are of good form although there is the usual tendency of this species to make crooked boles. Scotch pine is quite intolerant, more so than either red or white pine. So far as can be judged from 20 years of growth, Scotch pine is an excellent tree for use on sandy soils provided it does not have to compete with hardwoods. Compare with Plot 14 for the effects of hardwood competition and with Plots 22, 24, 28 and 49 for the results from planting other species at the same time and under approximately the same conditions.

A few trees infected with *Peridermium pyrifforme* have been removed from this plot but the disease does not seem to have made much headway and little trouble is expected from it with this species.

In 1919 students from the Yale School of Forestry laid off and thinned a sample plot covering .089 acre. After thinning there were left on this plot 122 trees which is at the rate of 1,370 per acre. The volume of these trees was 96.3 cu. ft. * of wood or 1,083 cu. ft. per acre.

In 1924 this sample plot was thinned again removing 50 trees or 562 per acre and 39.9 cu. ft. of wood or 448 cu. ft. per acre. After this second thinning there were left 72 trees or 808 per acre and 89.2 cu. ft. of wood or 1,002 cu. ft. per acre. The increase on this plot for the 5 years 1919-1924 had therefore been at the rate of 368 cu. ft. per acre, or 74 cu. ft. per acre per year.

In 1920 another sample plot covering .0804 acre was laid off as a check for the one described above and left unthinned. The number of trees on this plot was 167 or 2,077 per acre and the volume 111.9 cu. ft. or 1,392 cu. ft. per acre. This plot was remeasured again in 1924 at which time there were 151 trees (16 having died from natural causes) or 1,878 per acre. The volume of these was 135.05 cu. ft. of wood or 1,679 cu. ft. per acre. The increase for the four years 1920-1924 had therefore been 287 cu. ft. per acre or 72 cu. ft. per acre per year. Both sample plots will be remeasured and the thinned plot will be thinned again in 1929.

Plot 24. Austrian pine—Red pine—White pine. Area .4 acre. Planted as follows: south end, Austrian pine 4 year seedlings, spaced 4 x 5 feet, summer of 1902; center, red pine 4 year seedlings, spaced 4½ x 5 feet, spring of 1902; north end, white pine, spaced 4½ x 5 feet, 1905.

The plot is chiefly red pine, the Austrian and the white consisting of two blocks of about 100 trees and 50 trees respectively. The white pine being younger is not compared with the others. The Austrian averages 23 feet tall and 4 inches in diameter and the red 21 feet tall and 3 inches in diameter, but the former tends to have a crooked bole. The Austrian pine has dead branches for 10 feet above ground while the red pine has them for only seven. A carpet of needles 2 to 3 inches deep covers the ground and all vegetation has been shaded out. Red pine on this plot, as well as on Plot 22, has not grown as fast as Scotch pine on Plot 23, but is straight boled and generally of better form than the latter. The fact that the Austrian pine averages greater in height and diameter than the red pine may be due to the fact that the total number of the former is relatively small and a greater percentage of the trees border on roads which gives them more growing space. Austrian pine on Plot 24 has been subject to a small amount of infection by *Peridermium pyrifforme* but little damage has resulted.

In 1920 students from the Yale School of Forestry laid off a sample plot covering .0919 acre in the red pine. The results of

*Volumes computed from Table 27, Bulletin 13, U. S. D. A., revised and extended to cover the sizes of trees found on this plot.

the counts and measurements were: number of trees 162 or 1,763 per acre; volume 82.4 cu. ft.* of wood or 897 cu. ft. per acre. This sample plot will be remeasured and thinned and a check plot established in 1925.

Plot 25. White pine, wild stock. Area .8 acre. Planted in the spring of 1902 with collected seedlings 8 to 18 inches tall from Granby. Fail places were filled in 1903 with hardwoods, which died and were replaced with wild stock in 1905. Spacing $4\frac{1}{2} \times 5\frac{1}{2}$ feet. Practically all the pines planted are present but a considerable number are dead from crowding. Heights average 23 feet and diameters 4 inches. Dead branches extend for 7 feet above ground and are small but quite persistent. Weevil damage has been relatively small, due possibly to close spacing. As an experiment in the use of wild stock this plot is a success but at present it would probably cost more to collect such stock than to buy it from a nursery. Compare with red, Scotch and Austrian pine on Plots 22, 23 and 24, and with other white pine from nursery stock on Plots 12 and 28.

Note. The form of the crowns on Plot 25 is quite different from those on Plot 28 which was planted at the same time but with nursery stock. On the latter plot the side branches are quite long, project nearly in a horizontal plane, are interlocking and are dead for 9 feet above ground. The crowns of the wild stock have short slender branches which tend to grow upward. They do not seem to have interfered with each other greatly and are dead for only 7 feet above ground. The general appearance of Plot 25 closely resembles that on 12 where nursery stock was planted and remained for nearly 10 years under a dense cover.

Plot 26. White pine with various spacings. Area 1.2 acres. Planted in the spring of 1903 with 2 year transplants spaced 6 x 6 feet on the south end, 5 x 5 feet in the center, and 4 x 4 feet on the north end. Failures amounting to about 10% occurred in each section. At the end of 10 years the trees with the 4 x 4 foot spacing had made the best growth but at 20 years the 6 x 6 foot spacing had produced larger trees than either of the others, the average being 20 feet in height and 4.3 inches in diameter. The 5 x 5 foot spacing is next with a height of 16 feet and a diameter of 3.5 inches, and the 4 x 4 foot spacing last with a height of 14 feet and a diameter of 2.2 inches. The trees with the 4 x 4 foot spacing showed the greatest height growth between the 8th and 12th years, falling off after that time. Those with the 6 x 6 foot spacing have grown rapidly since the fifth year. Those in the 5 x 5 foot section have grown slowly during the entire period. Damage by weevil has been heaviest in the 6 x 6 foot spacing and lightest in the 4 x 4 foot.

*Volumes computed from Table 27, Bulletin 13, U. S. D. A., revised and extended to cover the sizes of trees found on this plot.

Vegetation has been killed out in all three sections and 2 to 3 inches of needles cover the ground. With all three spacings, trees have dead limbs for 7 feet above ground, but this amounts to about 50% of the total height in the 4 x 4 foot section and only 30% in the 6 x 6 foot. All dead limbs are quite firm. Those on the 6 x 6 foot spacing are much larger than on the others. Because it results in less injury from weevil and in the production of small side branches, the 4 x 4 foot spacing would be more satisfactory if thinnings could be made at about the fifteenth year. As this is not feasible, it is probably better to grow this species with a wider spacing, attempting to get protection from weevil and to prevent the growth of side limbs by using a hardwood cover, and thinning it gradually for the first 15 years.

Plot 27. White pine. Area 1.0 acre. Planted in the spring of 1904 with white pine 2 year seedlings and chestnut 1 year seedlings, 2 rows of pine and 2 rows of chestnut, spacing 5 x 5 feet. The chestnut failed and the chestnut rows were filled in the spring of 1910 with white pine 4 year transplants spaced 6 feet apart in the rows. The results of using white pine as a filler in an older plantation of the same species are not entirely satisfactory. The older pines are bushy with no dead limbs and have been heavily damaged by weevil. They average 17 feet in height and 4.4 inches in diameter while the 1910 trees average 11 feet in height and 1.8 inches in diameter. The latter show only a 10% damage by weevil and are generally of good form. The plot as a whole is quite ragged and uneven and has not closed. The 1910 planting may, because of better protection from weevil and side crowding from the 1904 trees, develop into a stand of good form but the final results will probably not be as good as if the stand were even-aged throughout. This plot may be compared with Plots 4, 35, 36, 37 and 56 where Scotch pine was used as a late filler.

Plot 28. White pine. Area 1.6 acres. Planted in the spring of 1902 with 3 year seedlings and 4 year transplants. Failures were replaced 1904-5 with transplants. A part of this plot was cultivated and fertilized for several seasons but no results of this treatment are apparent. Spacing 4 x 5 feet although many trees are only 3 feet apart and often two or more were planted together. The resultant stand is very dense and many trees are dying from lack of space. Average height, 19 feet; diameter, 3.5 inches. Dead branches extend for 9 feet above the ground and are small but persistent. Weevil damage has been slight. The stand shows the effect of too keen competition and should be thinned immediately in order not to further reduce the amount of living crown. This plot does not compare favorably with Plots 22, 23 or 24 where red and Scotch pine were planted at the same time and with about the same spacing. The stand should have been thinned at 15 years. All vegetation has been shaded out and several inches of needles cover the ground. (See note under Plot 25.)

In 1920 students from the Yale School of Forestry laid off a sample plot covering $\frac{1}{8}$ of an acre. The results of the counts and measurements were: number of trees 245 or 1,960 per acre, volume 95.6 cu. ft.* of wood or 764.8 cu. ft. per acre. This sample plot will be remeasured and thinned and a check plot established in 1925.

Plot 29. White pine. Area 2.3 acres. Planted in the fall of 1907 with 3 year transplants, spaced 5 x 5 feet, to test the results of fall planting. The experiment is a moderate success, less than 25% having failed. The stand as a whole, however, is quite ragged and uneven due to the blanks and to the fact that some individuals have grown very slowly. Weevil damage has been quite heavy. Crowns have not closed enough to kill the lower branches and shade out herbaceous growth. The plot was cleared of birch in 1919. Heights average 15 feet and diameters 3.5 inches. For other examples of fall planting see Plots 7 and 69a.

Plot 30. Jack pine. Area .3 acre. Planted in the spring of 1908 with seedlings from Michigan 1 to 2 feet high, spaced 5 x 5 feet. A 50% failure resulted and the present stand is rather open and uneven. It has not yet closed sufficiently to kill the lower branches or to shade out herbaceous cover. Although a few individuals have done well, generally the trees have crooked boles and long side branches. Average height, 16 feet; diameter, 3 inches. In 1910 several trees infected with *Peridermium cerebrum* (See page 106) were removed. This disease was evidently introduced with the stock as no further infections have been found. This pine is bearing cones prolifically and many seedlings up to 12 inches tall may be found in the openings. The plot should be compared with Plot 47 where Jack pine was used as a late filler.

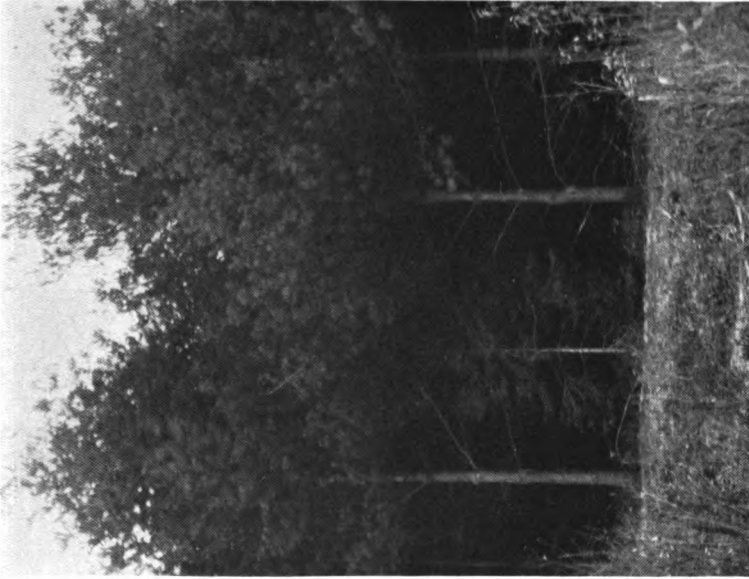
Plot 31. Scotch pine. Area .3 acre. Planted in the spring of 1903 with green ash 1 year seedlings, spaced 10 x 10 feet. In the spring of 1904 Scotch pine 2 year seedlings were planted 5 feet apart in solid rows between the ash rows and alternating with the ash in the rows, making the final spacing 5 x 5 feet. The ash failed thereby reducing the density 25% and this, plus a 5% failure in the pine, leaves the plot about 70% stocked. The stand is very dense and has completely closed. Average height 25 feet; diameter 4.8 inches. Dead limbs extend for 12 feet above ground and the lower ones, though still persisting are quite rotten. They seem to be a little larger than on Plot 23. From the appearance of this plot it would seem that Scotch pine may be planted with a much wider spacing, 7 x 7 or 8 x 8 feet, and still close and prune satisfactorily. The effect of this would be to delay the first thinning until the stand was 30-35 years old when the operation

*Volumes computed from Table 27, Bulletin 13, U. S. D. A., revised and extended to cover the sizes of trees found on this plot.

PLATE I



a. Plot 38. Douglas fir and white pine planted in 1903.
Note the great variation in size of the fir.



b. Plot 69. Norway spruce and white pine planted in 1905 in the open. The pine has overtopped 90% of the spruce.

PLATE II



a. Plot 5. Japanese red pine planted in 1910. Note the bushy habit of this species when grown in the open.



b. Plot 42. Norway spruce and white pine planted in 1906 under an overwood which has since been removed. The spruce is holding its own with the pine. Compare with Plate I b.

PLATE III

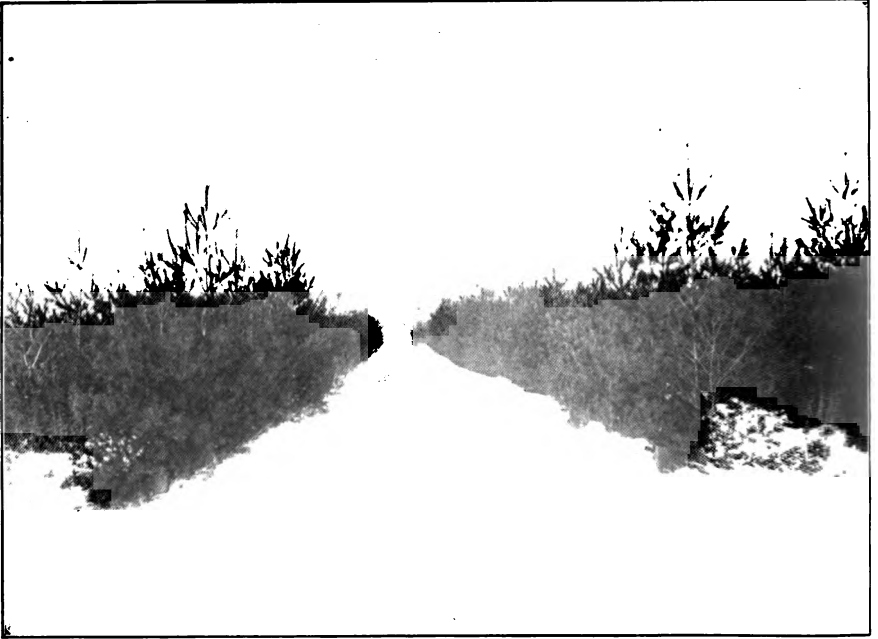


a. Plot 30. Jack pine planted in 1908.



b. Plot 68. White pine planted in 1905.

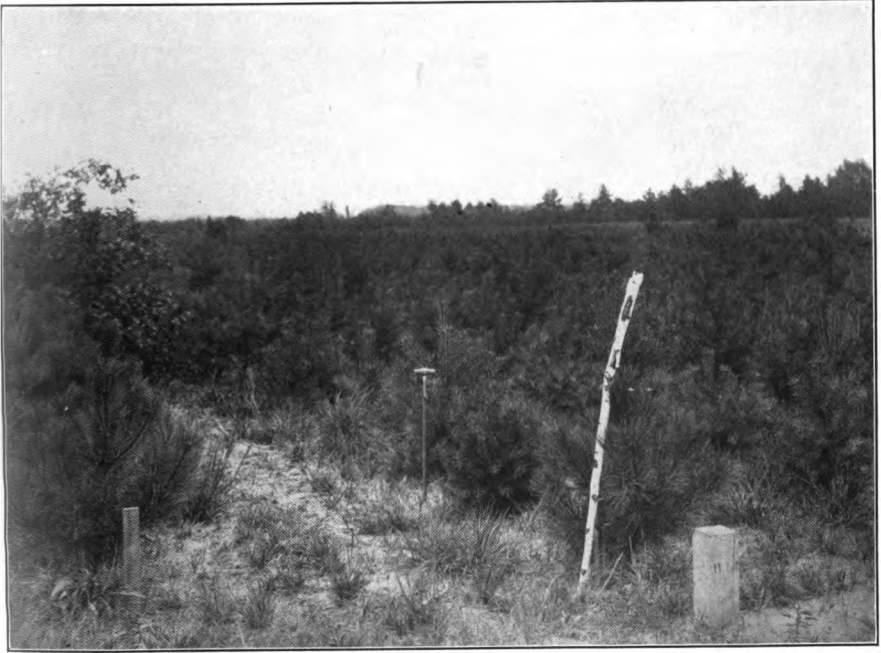
PLATE IV



a. Fire line between Plots 60 and 68 in 1912. Compare with Plate VII b.



b. Looking north across Plot 23 in 1903, one year after Scotch pine was planted. Note character of ground cover.



a. Red and Scotch pine on Plots 22 and 23 in 1905.



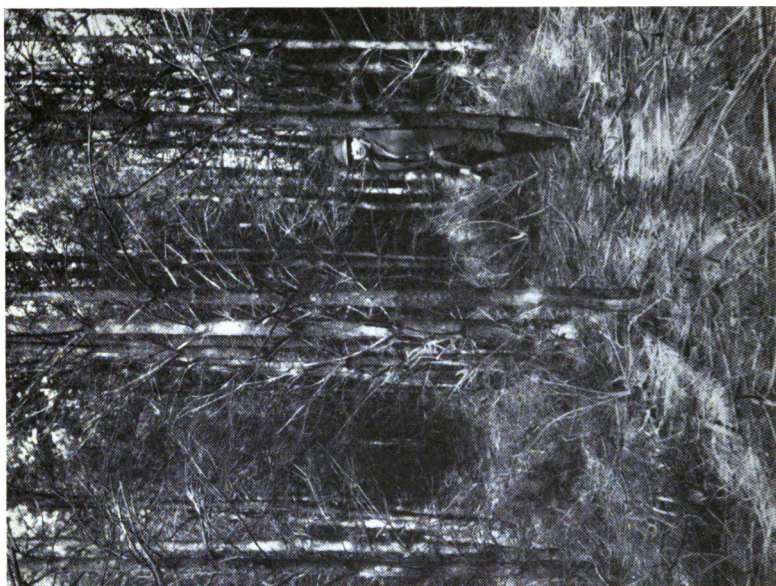
b. Red and Scotch pine on Plots 22 and 23 in 1912.

PLATE VI



a.

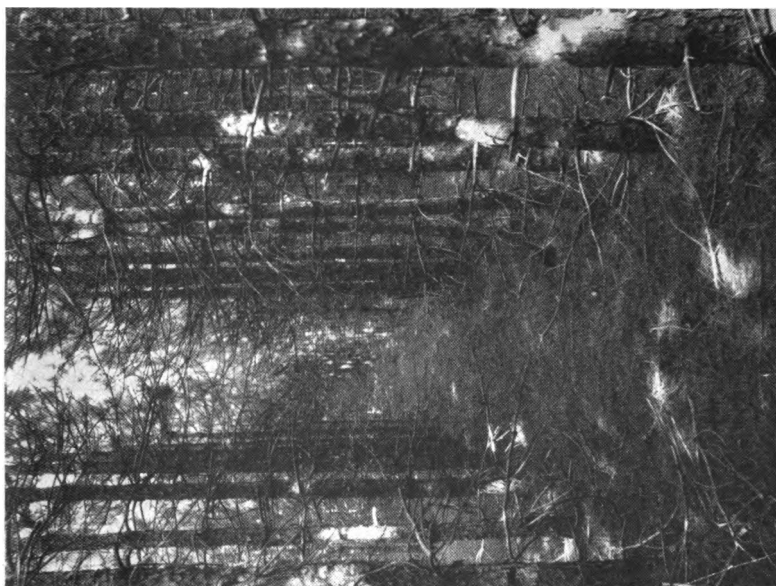
a. Thinned in 1919 and 1924.



b.

b. Left unthinned as a check.

PLATE VII



a. Plot 24. Red pine planted in 1902. Compare with Plate VI.



b. Fire line between Plots 60 and 68. See Plate IV a.

PLATE VIII



a. Plot 6. Bull pine planted in 1908, white pine in 1913. Bull pine with the axe leaning against it was killed by the rust.



b. Plot 16. Red pine planted in 1917.

would probably more than pay for itself. The trees are bearing cones prolifically and seedlings up to seven years old may be found around the edges of the plot. All vegetation has been shaded out and a carpet of needles several inches deep covers the ground. Compare with Plot 23.

Plot 32. Norway spruce. Area 1.5 acres. Planted in the spring of 1905 with 2 year seedlings, spaced 5 x 5 feet, under an open growth of pitch pine and hardwoods. The ground had been burned over just before planting. A second fire burned over a portion of the area in 1907 and in 1910 blanks were filled with 4 year transplants. In 1911 a 50% failure had resulted and in 1913 all blanks were filled with 7 year transplants after removing a part of the overwood. In 1923 a fire burned over about $\frac{1}{3}$ of the plot near the East Granby highway. This has not been replanted. Exclusive of the recent burn the plot is now only about 50% stocked. The trees seem well established but average only 4 feet in height and show the effect of too dense cover. With the removal of the overwood the stand should recover and increase in height rapidly although it will always be quite open. A few trees of another species, probably white spruce, occur near the southern edge of the plot, also an occasional balsam fir. Many trees, both of Norway and the other spruce, are heavily infested with galls. (See page 106.)

Plot 33. White pine. Area 2.1 acres. Planted in 1905 with 2 year seedlings, spaced 5 x 5 feet, under a medium dense shade of pitch pine and hardwoods. The overwood was thinned in 1913 and birch was lopped back on the west side in 1923. The white pine has not made a rapid growth but the plot is 80% stocked (excluding a 1923 burn covering about a half acre) and the trees are of good form and have not been damaged to any extent by weevil. The white pines are growing into the crowns of the pitch pines and the latter should be removed. Heights average 11 feet; diameters 1.7 inches.

Plot 34. Scotch pine—White pine—Mountain pine. Area .9 acre. Planted in the spring of 1911 with 4 year Scotch pine transplants and 3 year mountain pine seedlings, spaced 6 x 6 feet. About 90% of the latter failed and the blanks were filled in the spring of 1913 with 5 year white pine transplants. About 20% of the Scotch and 10% of the white pine are missing. After the failure of the mountain pine the experiment resolved itself into determining the value of white pine as a filler in an older Scotch pine stand. The results are not promising. The Scotch pine has made a very rapid growth and has spread out so that it nearly closes over the white pine. In fact, it is quite probable that in a few years it will completely suppress the white and form a pure Scotch pine stand spaced 6 x 12 feet. This may prove a desirable density for Scotch pine as it will delay the need of thinning.

The Scotch pine now averages 11 feet in height and 3.1 inches in diameter, while the white is only 6 feet tall. The white pine has been weeviled but very little. As a whole the stand has not closed sufficiently to shade out herbaceous growth or to form a litter of needles. Compare with Plots 4, 35, 36, 37 and 56 where Scotch pine was used as a filler in an older white pine stand.

Note. The mountain pine proved to be of the Mugho variety. Mugho pine when crowded, will abandon its prostrate habit and send up a single stem. In several cases it has reached a height of 6 feet or more. It is attacked to a slight extent by the white pine weevil.

Plot 35. White pine and Scotch pine. Area 2.0 acres. The experiments started in 1903 as an example of mixed planting by groups. Two year transplants of white pine and various hardwoods were planted with a spacing of $4\frac{1}{2} \times 5$ feet and mixed by grouping 3 to 10 trees of each species together. Blanks in the pine were filled with 3 year transplants in 1904. The hardwoods practically all failed and in the spring of 1911 were replaced with Scotch pine 3 year transplants. The present stand is about $\frac{1}{4}$ white and $\frac{3}{4}$ Scotch pine minus a few blanks caused by failures. The white pine because of its greater age has made a bushy growth with long side branches. It averages 15 feet in height and 3.4 inches in diameter. Weevil damage has been quite heavy. The Scotch pine has grown rapidly and has nearly caught up with the white. It averages 13 feet in height and 3.2 inches in diameter. The stand is just closing and few trees show any dead branches. Herbaceous growth has been shaded out and 1 to 2 inches of needles cover the ground. The Scotch pine should overtake the white in a few years and it remains to be seen whether it will eventually suppress the white or not. The plot was thoroughly cleaned by lopping birch and girdling pitch pine in 1924. Compare with Plots 4, 34, 36, 37 and 56.

Plot 36. White pine and Scotch pine. Area .9 acre. Planted in the spring of 1903 with white pine 2 year transplants and maple seedlings alternating in the row and spaced 6×6 feet. Pine blanks were filled in 1904 with 3 year transplants. The maple failed and was replaced in 1908 with 2 year Scotch pine seedlings. The Scotch pine now averages 18 feet in height and 3.8 inches in diameter and the white, 16 feet in height and 3 inches in diameter. The stand has just closed. All herbaceous growth has been shaded out and 1 to 2 inches of needles cover the ground. Scotch pine has dead branches for a height of 5 feet and white pine for 3 feet. The Scotch was probably used too soon as a filler. It looks now as though it would soon close over and suppress the white, although the latter may respond to crowding with an increased height growth. Compare with Plots 4, 34, 35, 37 and 56.

In 1923 students from the Yale School of Forestry laid off a sample plot covering $\frac{1}{4}$ acre. The results of the counts and measurements were: number of trees—white pine 162, Scotch pine 125 or 648 and 500 trees per acre, respectively. Volume—white pine 57.4 cu. ft. of wood*, Scotch pine 66.8 cu. ft. or 229.6 cu. ft. and 267.2 cu. ft. per acre, respectively. This sample plot will be remeasured and thinned and a check plot established in 1928.

Plot 37. White pine and Scotch pine. Area 1.0 acre. Planted in the spring of 1903 with white pine 2 year transplants and maple seedlings, spaced 6 x 6 feet, solid rows of maple alternating with a row of maple and pine mixed. The maple was a failure and was replaced in 1911 with 3 year transplants of Scotch pine. Not over 10% of blanks now exist. The Scotch pine has surpassed the white in diameter and in height. It now averages 16 feet tall and 2.8 inches in diameter, while the white is 12 feet tall and 2.2 inches in diameter. The Scotch pine has dead limbs for 3 feet above the ground but the white has live limbs clear to the ground. The stand has closed, shading out herbaceous growth. About 1 inch of litter covers the ground. The white pine shows little weevil injury. Just why the Scotch pine is ahead of the white on this plot and behind it on Plot 35 is not apparent unless the grouping of the white pine on Plot 35 was more stimulating to height growth than the 12 x 12 foot spacing on Plot 37. Compare with Plots 4, 34, 35, 36 and 56.

Plot 38. White pine and Douglas fir. Area .4 acre. Planted in the spring of 1903, spacing 5 x 5 feet, the two species alternating in the rows. The pine has grown faster than the fir and now averages 18 feet tall and 4.6 inches in diameter, while the fir averages 10 feet tall and 1.3 inches in diameter. The early growth of the fir was very slow. This may have been due to the stock not being hardy because many trees have been killed back and deformed. However, the species seems to recover from this and to send up a new leader without any apparent deformation of the stem. The fir has not developed evenly, individuals varying from 1 to 16 feet in height. Some of this irregularity has been caused by suppression by pine. Fir produces a very narrow compact crown while pine, when given sufficient room, produces a wide crown. The result of this is that the stand has just closed and both species have live limbs clear to the ground. The fir seems quite tolerant and shows a considerable tendency to push through the pine crowns. Side limbs on the pine were cut back to favor the fir in 1923 and more of this work will be done in the future. During the last 5 years the fir has shown a greatly increased height

*Volumes computed from Table 27, Bulletin 13, U. S. D. A., revised and extended to cover the sizes of trees found on this plot.

growth and may in time catch up with the pine. It has held its own with the pine better than did Norway spruce planted under about the same conditions on Plot 69.

On account of the differences in crown habit it would seem advisable either to plant the fir about 5 years before the pine with the same spacing or to plant the two species at the same time with a closer spacing.

Plot 39. White pine. Area .7 acre. Planted in the spring of 1903 with white pine and hardwoods, the latter forming 75% of the mixture. The spacing was originally 5 x 5 feet but the hardwoods have failed and the pine is now spaced 10 x 10 feet. The results of this wide spacing are not entirely satisfactory. The pine shows a 50% injury by weevil. The stand is just closing, the side branches are large and long and have died for only a few feet above ground. Heights average 17 feet and diameter, 4.6 inches. All birch was removed from the plot in 1924. It is somewhat difficult to predict what the final results will be but it looks as if these short, large boled trees would produce a heavy yield of inferior lumber. A thinning will not be needed for at least another 10 years. Compare with Plots 4 and 59 for other examples of wide spacing and with Plot 28 for close spacing.

Plot 40. Red pine. Area .9 acre. Planted in the spring of 1924 with 2 year seedlings, spaced 8 x 8 feet, under a dense cover made up of grey birch and scattered trees from a red oak experiment which was a failure because rodents kept the trees cut back. At the end of the first growing season less than 10% of the red pines had failed. The plan is to remove all hardwood cover for cordwood after about 5 years.

Plot 41. White pine and Norway spruce. Area .2 acre. Planted in the spring of 1906 with 2 year seedlings, spaced 5 x 6 feet, under light brush, the species alternating by rows. Fifty per cent of the pine and 20% of the spruce failed. The birch cover was thinned in 1919 and completely removed in 1924. Both the pine and the spruce have been badly weeviled, probably because the plot is very narrow and open to a road on one side. The spruce is also attacked by galls. The two species average about the same in height, 12 feet, but the pine averages 3.5 inches in diameter and the spruce only 1 inch. Spruce has shown a greatly increased height growth in the last 5 years. Neither species shows dead limbs and in general the plot is quite ragged and has not closed. It may be compared with Plot 69 where these two species were planted in the open and the pine suppressed practically all the spruce.

Plot 42. White pine and Norway spruce. Area 2.6 acres. Planted in the spring of 1906 with 2 year seedlings, spaced 5 x 6 feet, the two species alternating by rows. Blanks were filled in

1911 with 5 year white pine transplants. At the time of planting an overwood of pitch pine and hardwoods, which varied in density from heavy on the south end to very open on the north end, covered the area. One acre in the densest portion of the overwood at the south end was cleared in 1911. In 1919, hardwood sprouts from the cutting in 1911, which has overtopped the planted trees, were thinned to give the conifers more light. The plot is now about 75% stocked and is rather uneven. The pine averages 15 feet in height and 2 inches in diameter and the spruce 11 feet in height and 1 inch in diameter. Neither species show dead branches for over 2 feet above ground. Both have been heavily damaged by weevil but the spruce is less deformed by the injury than the pine. The spruce is also heavily infested with galls. The effect of the cover has been to hold back the pine more than the spruce allowing the latter to hold its own with the pine. During the last few years the spruce has increased height growth enormously. Comparison may be made with Plot 69 where these two species were planted in the open.

Plot 43. White pine and Norway spruce. Area 4.2 acres. Planted in the spring of 1905 with 2 year seedlings, spaced 5 x 6 feet, the two species alternating by rows. Blanks were filled with 5 year white pine transplants in 1911. A medium dense overwood, chiefly pitch pine, covered the entire plot. This was removed from the south end in 1923. Both species have grown more slowly than on Plot 42 on which the cover was removed at an earlier date. The pine averages 10 feet tall and the spruce 6 feet. However, weevil damage has been very slight for both species and while the trees are not as large as on Plot 42 they are of much better form. Compare with Plot 69.

Plot 44. White pine. Areas 3.1 acres. Planted in the spring of 1906 with white pine 2 year seedlings, pure on the west side and mixed with maple on the east side. Spacing 6 x 5 feet. The maple failed and blanks were filled in 1910 with 4 year white pine transplants. Failures were filled again in 1911 with 5 year white pine transplants. An overwood of pitch pine and grey birch, varying in density from nothing at the south end to moderately dense in the middle and on the north end, covers the area. Over 80% of the trees are present. In the open they average 14 feet tall and 4.5 inches in diameter and under the overwood, 10 feet tall and one inch in diameter. Only in a few places has the stand closed and live limbs extend to the ground. Herbaceous growth has not been shaded out. A little spruce occurs at the north end, evidently an extension of Plot 43. The most marked feature is the almost entire absence of weevil injury and the smallness of side branches on the portion of the plot under the overwood. A cover of pitch pine is less harmful than is grey birch because its branches are stiff and therefore do not whip the white

pine tops as badly as do those of the birch. Several barren areas (see page 104) occur on Plot 44.

Plot 45. Mountain pine. Area 4.6 acres. Planted in the spring of 1912 with mountain pine, spaced 6 x 6 feet. The stock proved to be the Mugho variety of mountain pine and has been sold for ornamental purposes (See note on Mugho pine under Plot 34). A few Corsican pines from a planting which was made in 1910 and which was almost a complete failure, are scattered over the plot. They have made fair growth but are open grown and bushy. Barren areas (see page 104) similar to those in Plot 44 occur in Plot 45.

Plot 46. White pine—Norway spruce—Jack pine. Area .7 acre. Planted in the spring of 1906 with 2 year seedlings of white pine and spruce, spaced 5 x 6 feet, and alternated by rows. In 1908 fail places were filled with Jack pine. The composition of the plot is now 50% Jack pine, 25% white pine and 25% spruce. Jack pine has grown faster than the other two species averaging 21 feet in height and 4 inches in diameter. The white pine averages 18 feet high and 4.5 inches in diameter and the spruce, 10 feet high and 1.5 inches in diameter. Both spruce and white pine show a small amount of damage by weevil and the former is often infested with galls. The stand is almost entirely closed but there is only a small amount of litter. Jack pine has dead branches extending for 8 feet above ground, and white pine for 5 feet. Spruce has no dead branches. For the first ten years the spruce grew quite slowly but since that time, except where it was heavily shaded, it has increased its height growth enormously, often making 2-3 feet a year. Under stiff competition Jack pine develops well, forming a straight bole and small side branches which die early. This plot demonstrates its value as a late filler, for which it compares favorably with Scotch pine. About 2 cords of birch were removed from the plot in 1919 and a final release cutting was made in 1924. Spruce trees completely covered by pine will be sold as Christmas trees. This plan will also be followed on Plots 42 and 43. Compare Jack pine on this plot with that on Plots 30 and 47 where this tree grew more or less in open stands. Compare the white pine and spruce with that on Plots 41, 42, 43 and 69.

Plot 47. Douglas fir—Jack pine—Norway spruce. Area .9 acre. Planted in the spring of 1903 with Douglas fir and several hardwoods mixed at random and spaced 5 x 5 feet. Practically all the hardwoods failed and blanks were filled in 1908 with Jack pine. The fir is all on the east side of the plot and with the Jack pine and some spruce planted at a latter date forms a fairly good stand. The west side contains a scattering of Jack pine and a volunteer growth of birch and other hardwoods. Some chestnut

from the early hardwood experiment still persists but is kept killed back by the blight. The west side should be used for another experiment. The fir has developed in all respects about as it did on Plot 38. The spruce, being much younger, is mostly overtopped. Jack pine has developed much as it did on Plot 30 where it was open grown, i.e., it produced long side branches and crooked boles. It is bearing cones prolifically and numerous seedlings up to 7 feet tall may be found in the openings. The stand on the west side has not closed sufficiently to shade out herbaceous growth and there is almost no needle litter.

Plot 48. Red oak and White pine. Area .9 acre. Planted in the spring of 1904 with oak 1 year seedlings and pine 2 year seedlings, spaced 6 x 6 feet, 4 rows of oak alternating with 2 rows of pine. Eighty-five per cent of the oak and 70% of the pine are living but 50% of the oak have been kept cut back by rodents. These trees were excluded in the measurements. Oaks not attacked by rodents have done better than the pines and are crowding the latter severely. Oak averages 20 feet in height and 2 inches in diameter and pine averages 18 feet in height and 4 inches in diameter. The best oak on the tract is to be found on this plot. About half the pines have been injured by weevil and are of poor form. The thrifty oaks have dead branches for a height of 10 feet, but dead branches on the pine do not extend over 2 feet above the ground. Most of the pine limbs are small. The stand, as a whole, has closed and most of the herbaceous growth, except brake ferns, has been shaded out. There is very little litter on the ground. Considerable birch in the mixture helps to make the canopy quite dense. This plot is in need of thinning to give the better oak and pine a chance. Compare with Plots 4 and 51.

Plot 49. Pitch pine. Area .9 acre. Planted in the spring of 1903 with 2 year transplants, spaced 5 x 5 feet. Over 90% of the original trees are still living (except on thinned sample plot described below) but the stand is not thrifty. Average height, 15 feet; diameter, 3 inches.

In 1921 students from the Yale School of Forestry laid off and measured two sample plots of $\frac{1}{16}$ acre each and thinned one of them. The results of the counts and measurements for the unthinned plot were—number of trees, 131 or at the rate of 2,096 per acre; volume, 26 cu. ft.* of wood or 416 cu. ft. per acre: for the thinned plot—number of trees before thinning, 130 or 2,080 per acre; after thinning, 78 or 1,248 per acre: volume before thinning, 29.4 cu. ft. or 470.4 cu. ft. per acre; after thinning, 20.5 cu. ft. or 328 cu. ft. per acre. These sample plots will be remeasured and the thinned plot thinned again in 1926.

*Volumes computed from Table 27, Bulletin 13, U. S. D. A., revised and extended to cover the sizes of trees found on this plot.

The unthinned pitch pine on Plot 49 has apparently stagnated although the stand does not seem at all dense. Live crowns have been reduced to $\frac{1}{3}$ the total height of the tree. Pitch pine seems fairly tolerant of shade of older pitch pine but it does not seem able to stand side crowding. On this plot all trees had an equal amount of growing space and have developed about equally with no marked differentiation into crown classes. On the south half of Plot 3 this species has grown under quite different conditions, more nearly approximating those in nature. The number of seedlings that started was very large and competition during the earlier years quite keen. The stronger individuals developed rapidly, suppressing the weaker trees, thereby obtaining more room for the development of their crowns.

On the sample plot thinned in 1921, crowns are deeper and the trees are generally healthier than on the remainder of the area. Compare Plot 49 with Plots 3, 22, 23 and 28.

Plot 50. Red oak. Area .9 acre. Originally an experiment with red oak but rodents kept the trees cut back so badly that the result is almost a total failure. An occasional individual has not been attacked and has made good growth but these are so scattering as to be worthless as a test of this species. A volunteer stand of birch and pitch pine has taken possession of the plot.

Plot 51. Red oak and White pine. Area .9 acre. Planted in the spring of 1904 with oak 1 year seedlings and pine 2 year seedlings, spaced 6 x 6 feet, two rows of oak alternating with one row of pine. Practically all the oak are present but $\frac{2}{3}$ of them have been cut back by rodents. Those not cut back are ahead of the pine but are so scattering as to make the pine appear to be spaced 6 x 18 feet. The thrifty oak averages 19 feet in height and 2 inches in diameter, and the pine 17 feet in height and 5 inches in diameter. About 20% of the pine failed. Those living have been badly weeviled and are of poor form. They have closed in the rows but not between them. Herbaceous vegetation has not been killed out except directly under the pine and there is little litter on the ground. Compare with Plots 4 and 48.

Plot 52. White pine and Japanese red pine. Area .9 acre. Planted in the spring of 1910 with 2 year seedlings, spaced 6 x 6 feet, the two species alternating by rows. Loss in the Japanese red pine was heavy and blanks were filled about 1914 with white pine. The present stand is fully stocked and is 25% Japanese red and 75% white pine. Both species average 7 feet in height. Both have been weeviled, the white the more heavily than the other. The plot was thoroughly cleaned of birch in 1923. Crowns are just commencing to close, much herbaceous cover is still present and there is no litter on the ground. This plot is similar to Plot 5 and has received practically the same treatment except that the

leaders on the Japanese red pine have not been pruned back but left for comparison with Plot 5. Comparison may also be made with Plot 19.

Plot 53. White pine. Area .2 acre. Planted in the spring of 1905 with 2 year seedlings, spaced 5 x 5 feet. Blanks were filled in 1910 with three year transplants. All birch was removed by lopping in 1923. Several large pitch pine and clumps of birch held back or killed the white pine on part of the plot so that the stand is rather irregular and only about half the original number of trees is present. Dead branches extend for 4 feet above ground but are firm. Crowns have closed, resulting in a forest floor without vegetation and covered with 2 to 3 inches of needles. Fifty per cent of the trees have been damaged by weevil. Average height, 13 feet; diameter, 3.3 inches.

Plot 54. White pine and Japanese black pine. Area .9 acre. Planted in the spring of 1910 with 3 year seedlings of white pine and 2 year seedlings of Japanese black pine, spaced 6 x 6 feet, and alternating by rows. The Japanese species was apparently not hardy and 90% of it failed. Those living are only 2 feet tall and tend to have a prostrate habit. Twenty-five per cent of the white pine failed also so that the stand is only 40% stocked. The white pine has been heavily weeviled and is bushy and of poor form. It averages 7 feet in height. The plot was cleared of birch in 1923. Pitch pine is scattered over the plot but is not sufficiently dense to stimulate the white pine.

Plot 55. White pine. Area .9 acre. Planted in the spring of 1903 with 2 year seedlings from Maine, alternating in the rows with beech, spacing 6 x 6 feet. The beech failed and the experiment has become one of pure pine with a spacing of $8\frac{1}{2}$ x $8\frac{1}{2}$ feet. The stand is complete and is just closing. Lower limbs are just beginning to die and ground vegetation is almost completely shaded out. Average height, 17 feet; diameter, 4.5 inches. Fifty per cent of the trees have been injured by weevil. Diameter growth has been consistently large over the whole plot and the stand is thrifty, and in good condition except for weevil damage.

Plot 56. White pine and Scotch pine. Area .9 acre. Planted in the spring of 1903 with white pine 2 year seedlings and beech, spaced 6 x 6 feet, a solid row of beech alternating with a row of beech and pine mixed. In 1911 the beech was replaced with Scotch pine 3 year transplants. The white pine has made a large diameter growth averaging 4.5 inches, but a poor height growth, averaging only 17 feet. The Scotch pine, although 8 years younger, averages 16 feet in height and 3 inches in diameter. The mixture contains about 80% Scotch and 20% white pine. The stand has just closed and dead branches extend for 4 feet above ground. They are large and heavy on the white pine but short and slender

on the Scotch. Half the white pine has been damaged by weevil. Practically all ground cover has been shaded out and 2 to 3 inches of needles cover the ground. Compare with Plots 4, 34, 35, 36 and 37.

Plot 57. Red pine. Area .9 acre. Cleared of a scattered stand of large grey birches in the fall of 1923 and planted in the spring of 1924 with 2 year seedlings; spaced 8 x 8 feet. At the end of the first growing season less than 10% had failed. Compare with Plot 40 for a plantation of red pine made at the same time under heavy cover.

Plot 58. Black locust. Area 1.0 acre. Planted in the spring of 1903 with 1 year seedlings with various spacings. As far as growth is concerned this species has done better than any other used in the plantations, attaining a height of 35 feet and a diameter of 6 to 7 inches and reproducing itself prolifically. However, damage from the locust borer (See page 105) was so great that in the fall of 1923 the stand was removed for cordwood and the experiment abandoned. During the last growing season, sprouts have reached a height of 10 feet.

Plot 59. White pine. Area 1.0 acre. Planted partly in the spring of 1903 with white pine 2 year seedlings and partly in 1904 with white pine 3 year transplants alternating in the row with black birch and spaced 5 x 5 feet. A small portion of the plot was pure pine. The birch failed leaving the pine spaced about 7 x 7 feet on the average, although the spacing is somewhat irregular. Heights average 25 feet; diameters, 6 inches. Dead branches extend for 10 feet above ground and are moderately large and quite firm. Weevils have caused many crooked boles but in spite of this a good height growth has been maintained and the stand appears in good condition. Practically all herbaceous vegetation has been shaded out and 2 to 3 inches of needles cover the ground. This plot may be compared with Plot 39 for white pine with a wider spacing and with Plot 28 for a closer spacing.

In 1922 students from the Yale School of Forestry laid off two sample plots of $\frac{1}{4}$ acre each. One of these was thinned and the other left as a check. Measurements and counts were as follows: check plot, number of trees, 187 or at the rate of 748 per acre; volume, 219.1 cu. ft.* of wood or 876.4 cu. ft. per acre. Thinned plot, number of trees before thinning, 216 or 864 per acre; after thinning, 158 trees or 632 per acre: volume before thinning, 249.9 cu. ft. of wood or 999.6 cu. ft. per acre; after thinning 208.0 cu. ft. or 832 cu. ft. per acre. Both plots will be remeasured and the thinned plot will be thinned again in 1927.

*Volumes computed from Table 27, Bulletin 13, U. S. D. A., revised and extended to cover the sizes of trees found on this plot.

Plot 60. White pine. Area 2.1 acres. Planted in the spring of 1905, together with Plot 68, with 2 year seedlings, 3 year transplants and wild seedlings from Stafford. Spacing was 5 x 5 and 6 x 6 feet, and trees were set in old furrows and on mounds between. Both plots are the same in all respects and are described together. Both are in excellent condition. Trees average 20 feet in height and 4 inches in diameter. Weevil damage has been comparatively slight and little damage seems to have been done until the trees were 12 feet or more in height. Dead branches extend for 10 feet above ground and are small but quite firm. Herbaceous vegetation has been shaded out and several inches of needles cover the ground. Competition has not been too keen but a thinning is needed to prevent the stand becoming stagnated. These two plots contain the best growth of white pine on the tract.

Plot 61. White pine. Area 2.2 acres. Planted in the spring of 1913 with 5 year transplants, spaced 5 x 6 feet. A few clumps of chestnut sprouts still persist from a previous experiment. A moderately dense stand of grey birch covered the pine until 1923 when it was entirely removed by lopping. This cover does not seem to have been sufficiently dense to protect the pine from weevil as 30 to 40% of the trees have been damaged. Practically the entire planting survives. The stand has not yet closed, and bunch grass and other herbaceous growth still persists. The pine averages 9 feet in height and, in competition with birch sprouts that have come up since the cutting in 1923, should make a good height growth and produce only small side branches.

Plot 62. White pine and Scotch pine. Area 5.1 acres. Planted in the spring of 1907 with 2 year seedlings of white pine, spaced 5 x 5 feet. In 1922 a fire destroyed about 50% of the plot facing Plots 61-64 (measurements and counts exclude this burn). The stand has just closed and some herbaceous cover still persists. Plot was cleaned of birch in 1919. Weevil damage has been quite heavy averaging 35%. Average height, 17 feet; diameter, 3 inches.

The burn was replanted in the spring of 1924 with white and Scotch pine 2 year seedlings. The season was dry, the fire had reduced the tract to a barren sand plain, the stock was small and a very heavy loss resulted during the first growing season.

Plot 63. Red pine and White pine. Area 2.6 acres. Planted in 1917. The species were planted alternately 6 feet apart, in rows 10 feet apart with the idea that at some later date Scotch pine or some other species would be used as a late filler. This has not yet been done. The plot was cleaned of a heavy cover of birch in the spring of 1923. About 95% of the original trees are living. The red pine appears more thrifty and of better form than the white because the latter has been severely injured by weevil. Both species average 5.5 feet tall. The stand is just closing in the rows but not between.

Plot 64. Scotch pine. Area, 1.3 acres. Planted in the spring of 1910 with 2 year seedlings, spaced 6 x 6 feet. Subsequent loss has been rather heavy, due partly to failures at the time of planting and partly to suppression by birch. The birch was thinned in 1923 and completely removed by lopping in 1924. A number of medium sized pitch pines were girdled in 1924. This should be the final release cutting as the Scotch pine can probably take care of itself from now on. The stand is just closing but is rather ragged. Trees average 15 feet in height and 2.5 inches in diameter, and have dead branches for 3 feet above ground. Herbaceous cover still persists and there is little litter on the ground. The extreme intolerance of Scotch pine and the effect of cover on this species are well illustrated.

Plot 65. Red pine. Area .8 acre. Planted in the spring of 1917 with red pine, spaced 5 x 5 feet. There were practically no failures and the stand is quite thrifty except on a few sterile spots (described under Plot 16). A small fire in 1922 destroyed about 75 trees near Plot 66. A heavy birch cover was removed in 1923 but the red pine does not seem to have been held back to any extent by its shade. A few medium sized pitch pines were girdled in the fall of 1924, thus removing the last of the cover from the red pine.

Plot 66. Western yellow (bull) pine. Area 1.5 acres. Planted in the spring of 1908 with 2 year seedlings, spaced 5 x 5 feet. This plot is similar in all respect to Plot 6 except that the blanks, which amount to about 45%, have not been filled. The trees average 11 feet tall, somewhat larger than on Plot 6 but in general development has been similar to that on Plot 6. Bull pine seems to be quite intolerant. Individuals growing in the shade are stunted and, even when growing in the open, the lower branches die from the shade of those above. A ground fire burned over a small area in this plot in 1922 killing the bull pine completely. This species appears to be at least as susceptible to injury by ground fires as red pine.

Plot 67. Native pitch pine. Area .1 acre. No treatment.

Plot 68. White pine. Area 4.3 acres. (See Plot 60.)

Plot 69. White pine and Norway spruce. Area 3.6 acres. Planted in the spring of 1905 with 2 year seedlings, spaced 5 x 5 feet, the two species alternating in the row. Ninety per cent of the pine and 60% of the spruce lived but the pine has grown much the faster of the two and has overtopped about 90% of the spruce completely, making the plot in effect one of pure pine with a spacing of about 7 x 7 feet over an understory of spruce. In a few instances the spruce has grown rapidly and will probably catch up to the pine. The latter has long, heavy side branches which have died for 8 feet above ground but still persist. Weevils have

injured about 30% of the pines. Average sizes: pine, 22 feet tall and 4.5 inches in diameter; spruce, 5 feet tall. Overtopped spruce trees are being removed and sold for Christmas trees as fast as a market can be found for them. This plot demonstrates the fact that it is not feasible to plant spruce and pine in the open at the same time, as the pine grows much faster and completely overtops the spruce. Compare with Plots 41, 42 and 43 where an overwood has held back the pine more than the spruce, enabling the latter to hold its own with the pine. In 1913 a fire burned over about an acre in Plot 69 along the East Granby highway (See Plot 69a).

Plot 69a. Red pine. Area about 1.0 acre. Planted in the fall of 1920 with 3 year transplants, spaced 6 x 6 feet, under a scattering cover of grey birch as a test of fall planting. The experiment was a complete success. Ninety-five per cent of the trees are still living and the average height is 2½ feet. A few spruce and pine from the 1905 planting are scattered over the plot. All hardwood growth was removed by lopping in the fall of 1924.

Plot 70. Austrian pine. Planted in the spring of 1908 with 2 year seedlings, spaced 6 x 6 feet. The trees suffered heavily from drought and winter injury and at present less than 25% of the original planting is present. Heights vary from 2 to 10 feet and average about 3 feet. Most of the trees have crooked boles and, in general, appear sickly and show poor development. The plot was thoroughly cleaned by lopping back the hardwoods in 1923.

CONCLUSIONS.

Seeding versus planting. In general it may be said that experiments in regeneration by seeding were not successful. The seed of many species, both coniferous and hardwood, were sown by various methods but results were so poor that regeneration by seeding was soon abandoned. Even during the most favorable seasons the moisture conditions in the surface soil are very poor and it is often several years before any vegetation appears on land abandoned for cultivation. Grey birch, which usually reproduces quite prolifically on bare soil, does not come in readily on bare areas in this region. Planting, on the other hand has been quite successful. When this method has failed, the cause can usually be traced to using unsuitable species or to some other reason.

Hardwoods versus conifers. Of the many experiments with hardwood species, only three were successful enough to warrant comment. Red oak, black locust and chestnut seemed to thrive on poor soil when not attacked by enemies. Unfortunately all three species have been subject to animal, insect or fungous injury and are almost complete failures. The other hardwoods used have either died out completely or are represented by a few

stunted specimens. The conifers, on the other hand, have done well. Some have done better than others but only in one or two cases can an experiment with conifers be called a complete failure. From this it is apparent that the tract is far better suited to coniferous than to hardwood growth, mainly because the former are far less exacting in their moisture requirements than the latter.

Conifers. Three species stand out conspicuously above all others used. They are red, white and Scotch pine. Of these Scotch pine has grown the fastest during the juvenile period, i.e., the first 20 years. However, it is an European species and has not been brought to maturity in this country as a timber tree. There is, therefore, some uncertainty as to just how it will develop between the twentieth year and the time it is ready to cut. Should later development prove satisfactory, its value for planting on poor soils in this country may be very great on account of its rapid growth. Its worst fault seems to be a tendency to form crooked boles. One of the greatest values is as a filler in older plantations of other species where failures have occurred. The wood is somewhat similar to that of red pine and is a little harder and heavier than that of white pine.

The growth of red and white pine is about the same. White pine is a well-known species and its wood is very valuable, more so than that of red pine, although, where they grow naturally together, both species are marketed as white pine. Red pine has no serious enemies. Its form is normally very good and it prunes itself better than white pine under the same conditions. The latter has several enemies, the worst of which in this region is the weevil. This insect causes a large percentage of the trees to form crooked boles which yield inferior lumber. For these reasons the red pine is considered the better of the two species.

Norway spruce, another European species, has done very well when planted under shade sufficiently dense to act as a nurse but not heavy enough to suppress the trees. As in the case of Scotch pine, there are no stands old enough to furnish data on what its later development will be.

Jack pine, which grows naturally on very poor soil in the Lake States, has not done well in pure stands where it forms crooked boles and long side branches. When used as a filler in older stands where it is obliged to grow rapidly in order to survive it does well, having much better form than when grown pure.

Western yellow (bull) pine is not recommended for this kind of site. It has grown slowly and is subject to a fungus disease which threatens to kill out the species here.

Two other European pines, Austrian and Corsican, have not proved satisfactory. In one instance Austrian pine did fairly well but in general losses with both species were heavy at the time of planting and the experiments with them are failures.

Pitch pine has proved as unsatisfactory as it is when it grows naturally. Its form is not good, its growth is slow and on the whole it may be called a worthless species in this region.

Of the two Japanese pines used, the Japanese black was a total failure because it was not hardy. The Japanese red pine shows considerable promise if handled properly. It has a strong tendency when quite young to divide at the base into several stems and form a bushy tree. When severely crowded, however, this species will normally produce only one stem and in such cases the trees make an excellent height growth.

The value of Douglas fir on sandy soil is questionable. The development of this species is exceedingly variable, some individuals having done very well while others are much stunted. During the last five years this tree has shown up much better than it did previously.

The European larch is another tree which varies greatly in growth, some individuals having equalled the Scotch pine in size while others are mere shrubs. Its value on poor soil is probably small.

White spruce has been used too recently to furnish any data on how it will develop.

The other conifers found on the tract, two species of fir and one of arbor-vitae, are too few in numbers to merit comment.

Hardwoods. Only three of the hardwoods used need mention. They are red oak, black locust and chestnut. When not attacked by rodents red oak makes a height growth equal to white pine and is of good form, indicating that this species is adapted to poor soils. However, rabbits kept so many trees cut back that the stands are open and the experiments are failures. Without exception, black locust made the best growth of any species used on the tract but the trees were so completely mined by the locust borer that the plantation had to be abandoned. Chestnut once grew naturally on the tract. It is difficult to say what the results of artificial regeneration of this species might have been. The fact that much chestnut still persists, even after being killed back repeatedly by the blight, indicates that this tree might have been profitably grown on this site.

Other hardwoods used, but which were complete failures, were white oak, green ash,* tulip,* black birch, hard maple,* beech, catalpa, cotton wood, white ash and hickory.*

*No trees of these species were found in the 1924-survey.

LIST OF SPECIES USED ON EXPERIMENTAL PLOTS.

Following is a list giving the common and scientific names and the plot locations of the species used in the experiments.

White pine; *Pinus strobus*, L.*

Plot 2, 4, 5, 6, 7, 11, 12, 15, 16, 17, 20, 21, 22, 24, 25, 26, 27,
28, 29, 33, 34, 35, 36, 37, 38, 39, 41, 42, 43, 44, 46, 48,
51, 52, 53, 54, 55, 56, 59, 60, 61, 62, 63, 68, 69.

Red pine; *Pinus resinosa*, Ait.

Plot 8a, 16, 17, 22, 24, 40, 57, 63, 65, 69a.

Scotch pine; *Pinus sylvestris*, L.

Plot 1, 4, 14, 17, 20, 21, 23, 31, 34, 35, 36, 37, 56, 62, 64.

Pitch pine; *Pinus rigida*, Mill.*

Plot 3, 49.

Austrian pine; *Pinus Laricio* var. *austriaca*, Endl.

Plot 1, 24, 70.

Corsican pine; *Pinus Laricio*, Poir.

Plot 45.

Jack pine; *Pinus divaricata*, Du Mont de Cours.

Plot 30, 46, 47.

Western yellow pine; *Pinus ponderosa*, Laws.

Plot 6, 66.

Japanese red pine; *Pinus densiflora*, Sieb & Zucc.

Plot 1, 5, 16, 19, 52.

Japanese black pine; *Pinus Thunbergii*, Parl.

Plot 54.

Mountain pine; *Pinus montana*, Mill.

Plot 34, 45.

Mugho pine; *Pinus montana* var. *Mughus*, Willk.

Plot 17, 34, 45.

Douglas fir; *Pseudotsuga Douglasii*, Carr.

Plot 1, 17, 38, 47.

Balsam fir; *Abies balsamea*, Poir.

Plot 13, 32.

White fir; *Abies concolor*, Lindl. & Gord.

Plot 17.

European larch; *Larix europea*, de C.

Plot 1, 17.

Arbor-vitae; *Thuja* sp.

Plot 17.

- Norway spruce; *Picea excelsa*, L.
Plot 8a, 8b, 10, 32, 41, 42, 43, 44, 46, 47, 69.
- White spruce; *Picea canadensis*, Mill.
Plot 18, 32.
- Red oak; *Quercus rubra*, L.
Plot 4, 17, 40, 48, 50, 51.
- White oak; *Quercus alba*, L.*
Plot 17.
- White ash; *Fraxinus americana*, L.
Plot 17.
- Black birch; *Betula lenta*, L.
Plot 59.
- Grey birch; *Betula populifolia*, Marsh.*
on nearly every plot.
- Beech; *Fagus americana*, Sweet.
Plot 20, 21, 55, 56, 57.
- Catalpa; *Catalpa* sp.
Plot 5.
- Cottonwood; *Populus deltoides*, Marsh.
Plot 6.
- Basswood; *Tilia americana*, L.
Plot 47.
- Chestnut; *Castanea dentata*, Borkh.*
Plot 7, 8a, 8b, 27, 57, 61, 63, 64, 65, 66.
- Black locust; *Robinia Pseudacacia*, L.
Plot 17, 19, 57, 58, 59.

*Found growing naturally, as well as where used in experiments.

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